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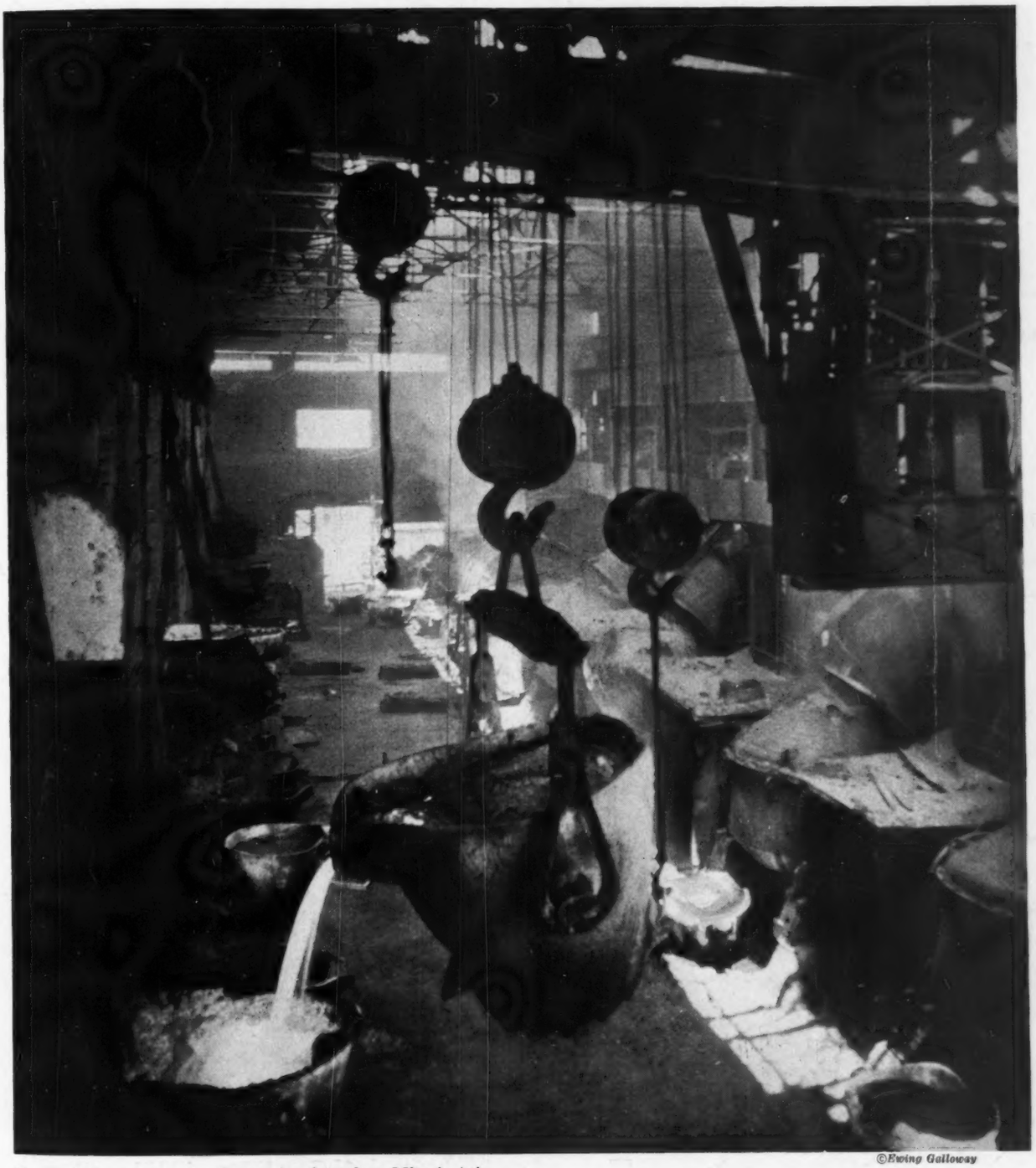

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ENGINEERING AND
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JOURNAL

A. W. ALLEN, *Editor*

VOLUME 130, No. 10

ESTABLISHED 1866

New York, November 24, 1930

Hope for Copper in Limitation of Output

NOT for a year or more could be sounded a cheerful note about the copper industry. As our readers know, the price rose too high, was held at eighteen cents longer than was justified, and has since dropped to an unconscionably low figure that has threatened wholesale hardship to the thousands of people dependent upon the copper industry for support. In short, the co-operative plans for stabilization, for which such high hopes were held two or three years ago, have not been a success. Patently, the scope of their application was too narrow.

In the last year there has been little inspiration to comment on the situation. Recently, apparently, only two courses were in prospect: either the low-cost producers would operate at capacity, forcing the less-fortunate companies to cease work, or a general curtailment to avoid further increase in stocks would be necessary. For the good of the entire industry, including the consumer, the latter course has been adopted, and with excellent prospects for success.

No one will gainsay the fact that a "gentlemen's agreement" has been consummated, to limit production for the purpose of raising the price. As such, it is open to criticism by any radical who may feel that a strict interpretation of the Sherman Act would be for the good of the country as a whole. Prosecution is unlikely, however, if the agreement is adequate in scope and demonstrably sound in economics and morals; and not a means to boost copper prices to unjustifiably high levels, which we do not believe is its objective.

The Attorney General cannot be expected to guarantee immunity to those sponsoring the plan of curtailment that has been decided on. But, if such a constructive measure is not permitted to be put in effect as a remedy for economic conditions obtaining at present in the copper industry, as well as in the other industries of the United States, it will be high time again to consider the question of modifying anti-trust legislation and abandoning the theory on which the Sherman Act is based. Former Assistant Attorney General William J. Donovan, at a recent meeting of the oil producers, who are in a predicament similar to that of the copper industry, declared that the Sherman Act should not deprive men of the right to exercise intelligence in the conduct of their business. Under existing economic conditions, however, that is precisely what that Act does.

As was emphasized by *Engineering and Mining Journal* in 1927-28, the Sherman Act and the Clayton Act are anachronisms. The Sherman law, especially, was conceived in the belief and the conviction that the public —all the people—must be and needs to be protected from unfair and monopolistic exploitation by the leaders of industry. Its present alleged usefulness and justification rest on the assumption that business is conducted by an inner circle of conscienceless and unscrupulous operators. This thesis *Engineering and Mining Journal* does not and will not accept.

Representatives of the copper-producing interests throughout the world, who met recently in New York City, have done well. Their efforts to avoid a waste of human effort, of private property, and of copper resources, deserve success.

Gold Production Rises as Costs Are Lowered

ALMOST every study of gold production and currency problems published within the last few months, including the report of the League of Nations Gold Delegation, has taken a "bearish" view on the future of the gold-mining industry. Because the Witwatersrand area, in South Africa, is the predominant factor in current world gold production, the pessimists are particularly despondent. When the Witwatersrand is exhausted—and they agree that that will be soon—where will the world get its gold? The government mining engineer of the Union of South Africa expects a drop of 40 per cent in output by 1940. The cry has been raised before. In 1919, a prominent mining engineer prophesied that to expect the gold industry of the Witwatersrand to "hold its own for the next ten years is about as optimistic as one can reasonably be." Actually, however, production has increased 25 per cent since 1919.

In the meanwhile, all indications are that 1930 will be the best year in gold production since the World War, and that it will not be very far behind the record years of 1914, 1915, and 1916. In an accompanying table, figures for 1929 production of some important gold areas, accounting for 75 per cent of world output, are given, together with our estimates for 1930. These estimates are based on preliminary figures for the first six or nine months, with the exception of the estimate for the United States. That, frankly, is a guess. The slight increase estimated is based on higher returns from the Philippines, Alaska, Cripple Creek, the Tintic district,

Gold Production Costs (*a*)

Company Mines	Ore Treated (Short Tons)	Gold Output (Oz.)	Grade (Oz. per Ton)	Operating Expenses Total	Operating Expenses Per Oz.	Depreciation Total	Depreciation Per Oz.	Total Cost Per Oz.
Modder Deep	531,500	280,664	0.53	$2,027,606	$7.22	.....	....	.....
Teck-Hughes	340,675(*b*)	261,998	0.77	1,970,336	7.52	$215,384	$0.82	$8.34
Ashanti (*d*)	128,588	157,412	1.22	1,221,592	7.76 (*c*)	148,716	0.94	8.70(*c*)
Government Gold	2,416,000	1,086,165	0.45	8,609,139	7.92	.....	....	.....
New Modder	1,811,000	870,222	0.48	7,352,949	8.45	.....	....	.....
Benguet Cons	97,400	73,255	0.75	630,940	8.61	113,272	1.16	9.77
Lake Shore	467,648	318,180	0.67	2,736,946	8.60	510,469	1.60	10.20
McIntyre	550,495	213,292	0.39	2,431,164	11.39	258,304	1.21	12.60
Homestake	1,437,935	315,328	0.22	3,721,485	11.80	.....	....	.....
Dredges								
Pato	.....	30,565	....	321,442	10.51	24,300	0.79	11.30
Yuba	.....	106,282	....	1,130,721	10.64	.....	....	.....

(*a*) For last fiscal year available. (*b*) Includes a small quantity of tailing re-treated. (*c*) Does not include government royalty of 5 per cent. (*d*) Based on returns for July, August, and September, 1930, as plant has been remodeled and costs have been cut.

and Nevada's two new gold producers—Seven Troughs and Gold Hill. Base-metal curtailment may decrease the amount of byproduct gold by as much as 100,000 oz., but it should not entirely offset the increase from the districts listed.

Although much is heard of the increase in the cost of producing gold, resulting from the higher commodity price levels following the World War, seldom are compilations published of the actual cost of producing an ounce of gold at important mines. The statement was made in the Teck-Hughes annual report by the general manager that the company has probably the lowest gold-production costs in the world. A survey of available statistics indicates, however, that at least two other mines are contestants for the record, and that a surprisingly large amount of gold is produced at a cost of less than $12 an ounce.

The calculations made were based on "operating expenses," including charges for mining, milling, general account, and development. If the company put aside a sum for depreciation reserve, a separate calculation was made. Unfortunately, most of the Rand mines do not include depreciation in their accounts, and a strict comparison in all respects is not possible. On the basis of "operating expenses," Modder Deep is apparently the world's lowest-cost gold mine, followed by Teck-Hughes, Ashanti, and Government Gold Areas. The wide spread in the grade of the ore treated at these properties is of interest, and the achievement of Homestake is particularly notable.

No claims for completeness are made for the production-cost table. Undoubtedly several other mines produce gold for less than $12 an ounce. Because of the scarcity of cost data on dredging operations, only two companies that recover gold from alluvial operations are included in the table. Probably, if the figures were available, it would be seen that some gold dredges have even lower costs than Pato and Yuba.

Several of the companies listed do not report gold production in ounces, but simply give the value of bullion recovered. In such cases, the volume of output has been obtained by dividing $20.67 into the total value. For converting from pounds sterling into United States dollars, to permit comparison, a value of $4.86 per pound sterling was assumed.

The readjustment in commodity prices now taking place should result in even lower costs of gold production than obtain at present. The eleven operations cited are instances of how profitable an industry gold mining may be, under proper conditions. Given the necessary capital for development and intelligent prospecting, its predicted decline may be averted for many years.

World Gold Production, in Fine Ounces

Country or District	1929	1930 Estimated
Union of South Africa	10,412,325	10,620,000
Canada	1,928,308	2,100,000
United States	2,208,386	2,250,000
Mexico	617,376	635,000
Southern Rhodesia	560,813	550,000
Western Australia	377,176	410,000
Kolar, India	363,271	320,000
British West Africa	225,500	250,000
Belgian Congo	155,000	180,000
St. John del Rey, Brazil	108,880	125,000
Totals	16,957,035	17,440,000

Smoke Farming a Failure in the Iron Country

SMOKE FARMERS—those individuals who profit or seek to profit by suing metallurgical companies for damage, real or fancied, inflicted on their crops or lands by smelter smoke—have all too frequently proved themselves a nuisance to their victims. A crop that died and the possible existence of acid fume that may have killed it —these present a combination that even an unskilled lawyer may be able to depict convincingly in court as effect and cause. To be sure, this hazard, where it has existed, has at times led smelters to improve their practice, and thus, in a way, it has contributed in some degree to the art of recovering metals from ores. One case stands out, indeed, where the affliction was a blessing in disguise, the acid plant, which the smelter erected to dispose of its fume, soon proving more profitable than the metal-winning operation.

The Minnesota iron country possesses no smelters, with stacks from which to pour smoke and gas over the rolling countryside. Other scourges there are, to be sure, in particular the tax gatherer—misfortune enough, as the staggering sums mulcted annually from the mining companies bear witness. Some time ago, however, certain individuals discerned the possibility of getting money

from the iron companies by another means. They proposed to collect damages because of the smoke, blasting, and vibration resulting from the mining work in the open pits. Possibly they reasoned that the operators provided a fair target for imposition. If the tax collector could get away with the monies he collected, the till should be easy to tap again, particularly if the decision rested with a jury. If they imagined their claims were just they were guilty of surprising inversion of reasoning. Iron mining is the prime and basic cause of their presence in the iron country. Only if the damage suffered were deliberately inflicted or the result of gross and inexcusable carelessness, apparently, could any just ground for a damage suit be found. Fortunately, the jury decided in favor of the operator. Otherwise, the future would see an endless repetition of such cases.

Engineering's Advantages as a Vocation

A FAVORED SUBJECT for themes by college freshmen is the selection of a vocation, and rightly so, for the modern industrial scene presents to the ambitious youngster an unrivaled choice. In fact, so great is the variety that he is likely to be bewildered, to lose himself in a maze, and to fall into rather than choose the line of endeavor that he eventually follows. With relief, therefore, we direct attention to a youngster who, as early as the seventh grade of his public-school career, has fully made up his mind. No worries about the future has this student of the Bagdad school, in Arizona, whose plans for the future have been brought to our attention by Mr. George Thomas, manager of Bagdad Copper. His essay follows in full:

"When I get through high school, I am going to a school where they teach mining engineering. When I get done with this course, I am going to take an International Correspondence School course. Then I am going to get married. After I get married, I am going to try to get a job at the Verde Central. At first I think I will only get two hundred and fifty dollars a month. After five or six months I will most probably get five or six hundred dollars a month. When I get five or six hundred dollars a month I intend to get a Packard front wheel drive car."

Such is the enthusiasm of youth! To dampen this future engineer's ardor by pointing out that the Verde Central has just closed down, that to get the job before marrying might be advisable, that a young engineer is more likely to start at a hundred than two hundred and fifty dollars a month, and that the road to salaries that can support Packard cars is usually of a much greater length than can comfortably be traveled in six months, would be impossible; his speculations as to the future would merely be diverted into other fields.

The essay offers definite proof of the ease with which the gospel of the printed word can be absorbed by persons in the most remote districts. Advertising kindles desires over all the world. The young man at Bagdad probably shares his eagerness for a correspondence-school course and his longings for a high-powered vehicle with boys in Johannesburg, Valparaiso, and Glasgow.

Use and Re-use of Filter Aids

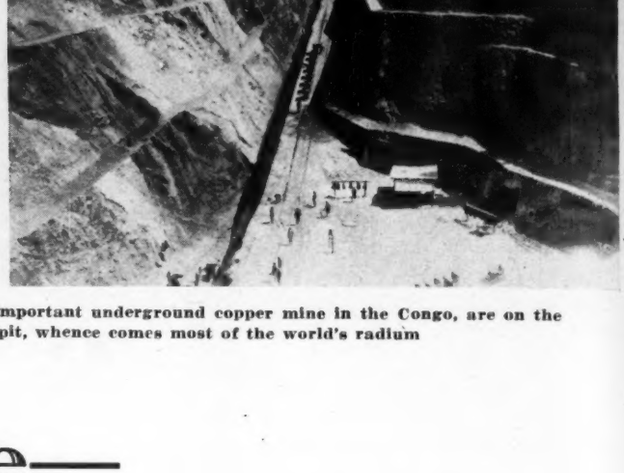
A RECENT CHAPTER in the history of petroleum development provides inspiration for other industries with problems to solve, as well as cause for satisfaction that opportunity exists for initiative and ingenuity. Much has been written on the freedom with which methods and equipment developed originally in the metallurgical plant have been borrowed for use elsewhere. A recent adaptation is worth recording. It concerns the re-use of mud employed in oil-well drilling.

The fluid vehicle used in such drill work must be heavy, with slow settling characteristics—to retain the rock cuttings. Former practice involved the wastage of this mud as it became contaminated with "impurities." The material cost was unimportant, but large settlement basins became necessary. One of these, in California, with a deposit fifty feet deep, covers from two to three acres. The expense of construction and maintenance is considerable.

Briefly stated, the problem was to remove the sand and rock cuttings, to liberate the entrained gas, to recover the oil, and to effect classification without final dilution of the mud. The Dorr classifier and the Dorr thickener —which, in experienced hands, have found application in so many industries since their invention as cyanide plant adjuncts—were utilized, the bowl-type classifier being adopted. Results are excellent—what any millman would have expected. The classifier produces a sand product and an overflow for the thickener, the underflow of which is a mud for return to the hole. A water-oil overflow from the thickener is later separated into (1) oil used for road surfacing, and (2) water that is available for the better operation of the classifiers. The capacity of the plant is about ten thousand barrels of mud per day and the simplicity and efficiency of the innovation are among its most attractive features.

The scope for ingenuity is unlimited, and the success of this plant suggests that opportunity exists for achievement in the problem of improving filtration of colloidal material, by the addition of crystalline material, to be used and re-used cyclically. Obviously, the idea is not new. Sugar refiners have used and re-used diatomite as a filter aid. The basis of one successful hot-solution, bulk-leaching process depends on the employment of water-soluble crystals to facilitate percolation, with part dissolution by water during washing, and re-deposition during subsequent employment of the solution as a lixiviant.

Large quantities of slime tailing are neglected because of the low permeability of the mass and inefficient displacement during pressure or vacuum filtration—the only practicable method of applying lixiviation. A filter aid, to be discharged as waste, is usually too costly. The work described in connection with rotary drill mud suggests that quartz sand or other crystalline material needed to facilitate percolation in leaching or filtration might be classified from the residue and returned for re-use. Bulk leaching, an efficient and frugal process, has been abandoned in many instances because of the channeling of the percolating solution, the result of the presence of excess slime. The metallurgical industry should give serious consideration to the opportunity for the employment of a filter aid that may be recovered from tailing and re-used.



The twin headframes at the Prince Leopold property, only important underground copper mine in the Congo, are on the left, and on the right is the Chinkolobwe open pit, whence comes most of the world's radium

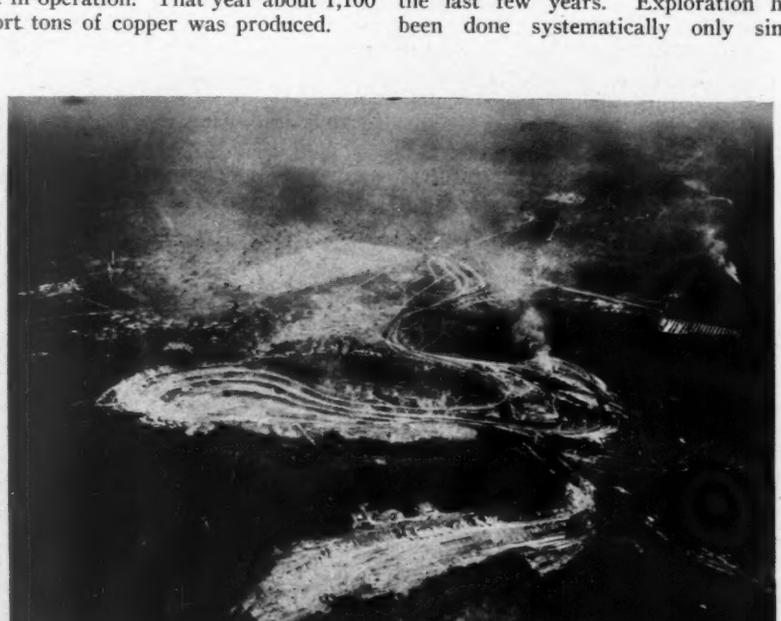
Union Minière—

Largest of the Copper Producers

THE annual report of Union Minière du Haut-Katanga shows that the company has wrested the title of world's largest copper producer from Utah Copper; and, according to present indications, may well keep it for several years. In 1929, Union Minière produced 151,000 tons of copper, compared with Chile's 150,000 tons and Utah's 148,000. Sir Robert Williams, vice-president of Union Minière, the man who is chiefly responsible for its inception and who has played a large part in its subsequent development, has predicted that the Belgian Congo producer may eventually attain an annual output of 300,000 short tons, or more than 15 per cent of current world production. Because of the richness of its ore—the grade treated last year was better than 6.5 per cent copper—and the tremendous extent of its holdings, Union Minière is undoubtedly destined to play a most important part in the copper market. For this reason, a booklet that the company has recently published, "Le Katanga, Pays du Cuivre," of which this article is an abridged translation, is of more than ordinary interest.

In 1906, Union Minière was formed to take over a concession comprising 15,000 square kilometers in Haut-Katanga in which deposits of copper had been discovered. The company also was granted an adjoining area as a tin concession. Both grants are to continue to 1990. Union Minière has since formed several subsidiaries for the manufacture of sulphuric acid, for hydro-electric power development, construction work, development and operation of coal mines, and transportation. It also controls Société Générale Métallurgique de Hoboken, which refines part of its output of blister copper as well as producing metallic radium, tin, and cobalt from Katanga ores. Production of copper by Union Minière started in 1911, when the Lubumbashi smelter was put in operation. That year about 1,100 short tons of copper was produced.

Copper deposits in the Katanga concession fall into three principal groups—Eastern, Central, and Western. Of these, only the mines in the Eastern and Central groups are now producing, but preparations are being made to develop and equip the Western mines. Developed ore reserves are estimated at 78,000,000 metric tons, containing more than 5,000,000 metric tons of copper. This figure has shown little change in the last few years. Exploration has been done systematically only since



An airplane view of the Kambove open pit

1916. Prospecting is difficult, because of the scarcity of outcrops and the heavy vegetation. The first deposits exploited were those where old workings indicated that the natives had produced copper. Geophysical methods have been introduced in the exploration work, supplementing drilling, and underground work. Seven copper mines, one iron mine which produces flux for smelting operations, two tin mines, one radium mine, and several limestone quarries are now under exploitation. Some of the copper deposits carry commercial quantities of cobalt. The total extraction of ores and minerals in 1929 was 4,500,000 metric tons.

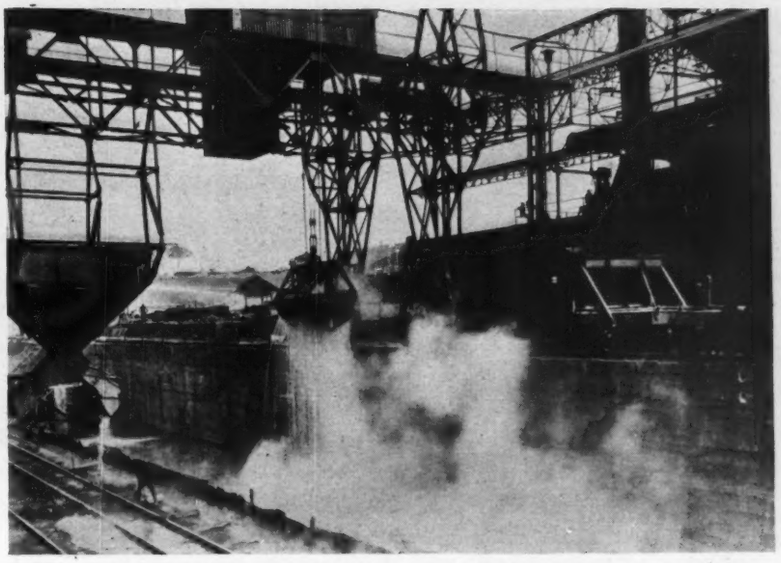
Mechanization has been applied to the mines as far as possible. At present, electric power from the plant at Elisabethville is delivered to the Ruashi property over a 15-km., 15,000-volt line and to the Prince Leopold property over a 30-km., 50,000-volt line. The other properties are being equipped to use electricity obtained from the new 45,000-hp. Chutes Cornet hydro-electric plant. The company now has twenty power shovels in operation at the open-pit mines, the majority, of course, being steam shovels. These units have individual capacities ranging up to 2-cu.yd. buckets, or about 1,000 metric tons of material daily. At the Ruashi mine, the overburden is removed by two cable ropeways, working in conjunction with the electric shovels.

At present the only property that produces a considerable tonnage by underground methods is the Prince Leopold. There, two shafts have been sunk 325 m. They are equipped to handle a combined tonnage of 600 metric tons per eight-hour shift. The Prince Leopold also has a plant for sawing and treating mine timber required underground.

The metallurgical centers of the company are at Panda, in the Central section, and Lubumbashi, near Elisabethville, in the Eastern section. At Panda, the plants include a concentrator, a smelter with reverberatory furnaces, and leaching, electrolytic, coal-pulverizing, and power units. At Lubumbashi, the original smelter, with water-jacket furnaces and one reverberatory, is still in operation, as are the subsidiary power and coal-pulverizing units.

Ore running from 6 to 10 per cent copper is concentrated in the mill at Panda, which has a capacity of 4,000 metric tons daily. Concentrate produced averages about 30 per cent copper. The plant is divided into crushing, gravity, and flotation sections, of which the first can handle 4,000 metric tons in eight hours. It consists of a 6,000-ton ore bin, four gyratory crushers, trommels, and roll crushers. After going through the gyratories, ore is hand sorted before going to the rolls.

In the gravity-concentration section, Hancock jigs and Wilfley tables handle the ore after grinding in ball mills, which operate in conjunction with classifiers and trommels. Concentrate obtained from this section is loaded directly into railroad cars for shipment to the smelter. About 40 per cent of the tonnage, classed as fines (material under 2.5 mm.), is treated in the Panda reverberatory furnaces. The coarse concentrate is shipped to Lubumbashi. Last year a total of 113,000 metric tons of gravity concentrate, averaging 29.1 per cent copper, was produced.



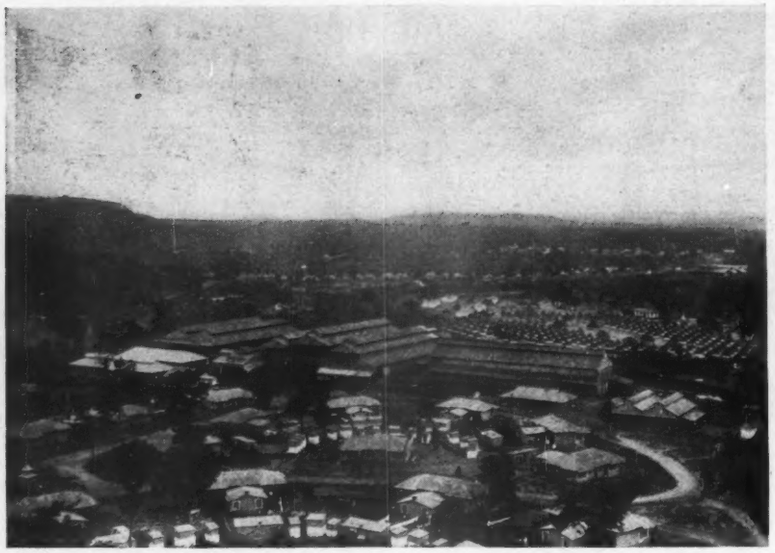
Automatic granulation of slag at the Panda smelter before it is sent to the dump

The residue from the gravity-concentration section has a grade of about 5 per cent copper. It is all treated by flotation. Standard practice is used in the flotation section, which has a capacity of 3,000 metric tons daily. Output of flotation concentrate in 1929 was 101,000 metric tons of 33.5 per cent copper. A test plant was built in 1928 to permit the company's metallurgists opportunity for experimentation that might lead to improvements in present practice, both in the gravity and flotation sections, as well as for evolving treatment methods for new minerals found at the mines.

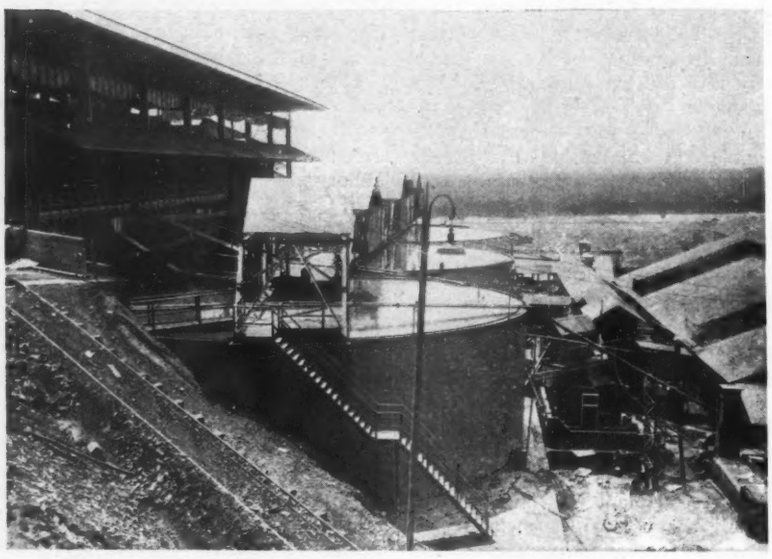
Until 1927 the only plant at Panda was the concentrator; but with the construction of the smelting and leaching units, the town has become the most important industrial center in the Belgian Congo. The smelter has eight five-hearth roasters and four reverberatory furnaces, 35x7 m. Capacity of the entire plant is about 1,000 metric tons of charge daily. Automatic handling insures the use of the correct proportions of iron ore and limestone for flux. High-grade ore, as well as the fine gravity and flotation concentrates, is treated at Panda. Pulverized coal is used both in the roasters and reverberatories. When built, the smelter had an estimated capacity of 30,000 to 40,000 metric tons of copper annually; but, in actual practice, as much as 60,000 tons can probably be produced.

During 1929, the leaching plant at

The glowing lights of the Panda smelter at night



Part of the native quarters form the background for the central shops at Panda



Thickener installation in the flotation section at the Panda concentrator

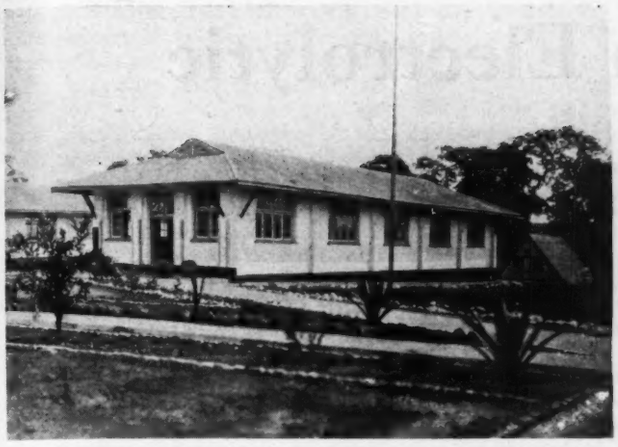
The Belgian Congo's first metallurgical center—the Lubumbashi smelter as it appears today

Chituru, near Panda, was put into operation. The plant, covering an area of 22½ acres, includes sections for ore crushing, stocking, drying and grinding, leaching, electrolysis, melting furnaces for casting in ingot form, and a plant for the manufacture of lead sheet used in the electrolytic tanks. Sulphuric acid for leaching solutions is furnished by "Sogechim," the company's chemical subsidiary. The leaching plant has an output capacity of 30,000 metric tons of electrolytic copper annually. Grade of finished product, which is shipped directly to consumers, is 99.95 per cent copper.

At Panda, power is furnished from a station having a total capacity of 35,000 kw. It includes two 12,500-kw. turbo-generators and two 5,000-kw. turbo-generators. Four boilers, using pulverized coal, furnish steam for the generators. The coal-pulverizing plant has a capacity of 800 metric tons of pulverized coal daily. The product is transported to the power and smelting plants by compressed air. In addition, the company maintains its principal machine shop at Panda, although most of the units have individual shops of their own.

Construction of the Lubumbashi smelter was started in 1910 and production started in 1911. The plant at present consists of eight water-jacket furnaces and one reverberatory, 30 m. long. Most of the material treated is high-grade ore, the reverberatory furnace being used for the treatment of fine material that cannot be smelted effectively in the water-jacket furnaces. Coke from the Wankie colliery, in Rhodesia, is used for fuel in the water-jacket furnaces, and pulverized coal is used in the reverberatory. The power plant consists of one 5,000-kw. turbo-generator and two 2,000-kw. units. The capacity of the coal-pulverizing plant, which furnishes the power-plant boilers as well as the reverberatory, is 200 metric tons daily. Seven blowers, with a combined capacity of 1,500 kw., furnish the blasts for the water-jacket furnaces.

Kakontwe, near Panda, is a center for the production of many of the essentials used in the Union Minière plants. Limestone quarries furnish the necessary flux for smelting. A brick factory manufactures both the refractory brick used for furnace lining and the ordinary brick for use in construction. Recently, a plant for the manufacture of cheddite, an explosive used in mining operations, has been completed, thus replacing in large part the dynamite formerly imported from the Union of South Africa. "Minoteries du Katanga," a subsidiary company, is engaged in milling cereals for consumption by native workers. The plants can handle 60 metric tons of corn and 24 metric tons of tapioca daily. At Luena, "Charbonnages de la Luena" is working the company's coal deposits, partly by



At the left is part of the hospital for colored workers maintained at Lubumbashi and at the right is a typical dwelling for married European workers

underground and partly by open-pit methods. In 1929, 100,000 metric tons of coal was produced.

Tin production of Union Minière in 1929 was 551 tons of concentrate from the Kikole and Kayumbo properties in the tin concession. Because of the distance from the railroad, and the scarcity of water to work the alluvial deposits during the greater part of the year, tin production is comparatively difficult. Concentrate is treated at the Hoboken plant, which has one tin furnace.

Radium production in 1929 was 60 grams—the largest in the history of the company. Ore is obtained from the Chinkolobwe mine and is treated at the Oolen plant of the Hoboken company. Union Minière now produces virtually the entire world output of the metal. Production of cobalt, in various forms, equaled 708 metric tons in 1929. Three electric furnaces have been built at Panda to treat copper ore with a high cobalt content. They produce an alloy, containing cobalt, copper, and iron, which is treated at Oolen. Canada is the only other important cobalt producer, and its output is about 40 per cent of that of Union Minière.

At present, Union Minière employs about 2,500 white workers and 17,000 colored in its various enterprises. The eight-hour shift is used. The company has built quarters for its employees at the different operations and maintains an extensive medical service, which includes 28 doctors, stationed at the various operating centers.

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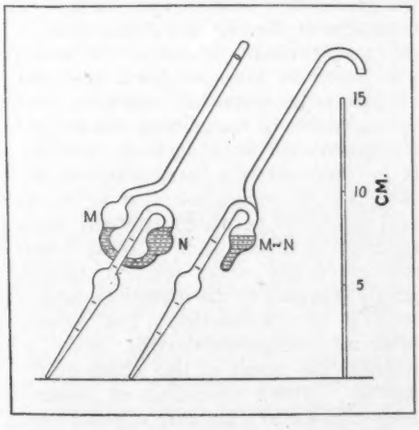
This New Pipette Offers Advantages

A NEW TYPE of pipette, described by E. L. Harrington in *Science*, and used at the University of Saskatchewan, has unusual features. The pipette, shown in the accompanying illustration,

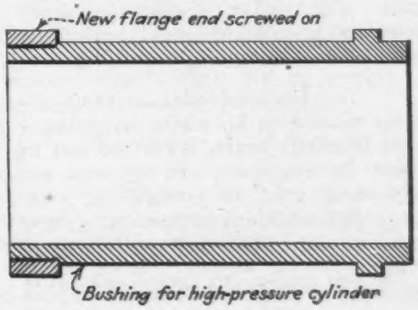


has a mercury plunger indicated by the letters *M N*. By inclining the pipette end and rotating it until the mercury fills the bulb *N*, the air is forced out of the tip. Inserting the pipette, still at the same angle, into the solution, and turning it, the mercury runs into bulb *M*, drawing the solution into the pipette to a height depending upon the angle of inclination and the amount of rotation, both of which may be definitely controlled. To expel any or all of the solution, the pipette is rotated in the reverse direction. For quantitative work the tube may be graduated. The pipette is superior to any type operated by suction, as it eliminates the danger of fumes or liquid being drawn into the mouth, as well as the possibility of contamination by moisture from mouth or breath. In many cases a pipette with a rubber bulb is used, but this method is not convenient, because of the difficulty of getting the precise quantity needed. Rubber bulbs also become contaminated, and the contamination is invisible. They are flabby, often leaky, and offer uncertain control of the position of the tip of the pipette, in contrast with the rigid new type. In using ordinary pipettes, the heat of the hand is likely to cause a vapor pressure high enough to expel some liquid in the pipette prematurely, especially when handling volatile solutions. In the new pipette the heat of the hand can have no effect, as the upper end is open. The bend at the upper end was added to allow hanging the pipette up when it is not in use.

Novel Repair Prolongs Life of Blowing Engine

AT THE power house of the American Smelting & Refining smelter at Hayden, Ariz., trouble was experienced with the high-pressure cylinder of an 18,000-cu.ft. blowing engine, according to Charles R. Clarkson, master mechanic. A careful inspection of the cylinder revealed a loose cylinder bushing, caused by one of its flange ends being worn 0.004 in., which resulted in a constant knock occurring within the cylinder.

With no spare available, the old bushing was made serviceable by severing the worn flange and, in its place, cutting a threaded section in the lathe to receive the carefully prepared and fitted ring serving as a new flange end, as shown in the accompanying illustration.



Manganese in Electrolytic Zinc Practice

[PART TWO]

Oliver C. Ralston

Director of Research,
United Verde Copper Company,
Clarkdale, Ariz.

R. B. Caples, who at the time of the action (February, 1927) described in the previous article was assistant general superintendent of the Great Falls reduction works of Anaconda Copper, testified as an expert for the Electrolytic Zinc Process Company. During all his work manganese was present in the ore and in the solutions. He had never operated with solutions free from manganese. The amount normally present in solution was 2 to 5 grams per liter. Caples was of the opinion that manganese in the solutions is normally neither an advantage nor a disadvantage, except that when present in large amounts the efficiency of zinc deposition suffers slightly. As far as Caples had experienced, manganese does not seem to aid in diminishing the resolution of the zinc deposit in the acid electrolyte. When the proportion of manganese reaches one part to every 25 parts of zinc, in a solution containing 10 per cent acid, the current efficiency starts to decline as compared with solutions containing less manganese. This was taken as evidence of the slight toxicity of manganese toward electrolytic deposition of zinc. Caples therefore criticized the French specification requiring one or more parts of manganese to every eight parts of zinc in the electrolyte. He was of the opinion that cobalt was one of the principal offenders in causing re-solution of the zinc, and also that manganese did not diminish the effect of cobalt. In this opinion Caples was evidently not supplied with the positive knowledge of Hey on the mischievous effects of manganese with cobalt. He felt French was correct in limiting his acidity to 2 per cent, because with higher acidity in impure solutions re-solution would have been prohibitive.

Unless Caples has more evidence to support his claim that manganese is mildly toxic, I am inclined to doubt the statement. In my own experimental work of synthesizing solutions with additions of pure manganese salts, the impurities in these salts have always been so super-toxic that they probably masked effects due to the manganese itself. Scores of manganese ores have been analyzed and found to carry nickel or cobalt, and no chemical manufacturer removes all of these when making manganese salts. Hence tests with increasing amounts of the manganese salt show increasingly bad effects.

It is conceivable that A. G. French could sincerely have reached the conclusion that the presence of manganese in the solution would permit a more reguline deposit of zinc. If French were testing clean lead anodes in comparison with peroxidized anodes (by this is meant lead sheets coated with lead peroxide resulting from several days' service as an anode in a sulphate solution), or with anodes coated with manganese dioxide scale, he would have obtained his poorest zinc in pure zinc sulphate solutions from the cells having clean lead anodes. This is because lead sulphate is not completely insoluble. Enough lead goes into solution to deposit on the cathode with the zinc. With enough metallic lead present at the cathode, violent re-solution may ultimately set in as the acidity becomes sufficiently high. An anode in use for a few days acquires a coating of lead peroxide or manganese dioxide, or both, and the cell yields progressively better cathodes. French easily could have confused these phenomena. Hence his claim about more reguline cathodes.

With regard to the effect of manganese in the solution on the cathodic deposition of zinc from sulphate solutions, the evidence in favor of any form of manganese as a beneficial addition agent or "dope" is decidedly sketchy and inconclusive. The evidence that manganese has a bad effect is somewhat more definite, but the claim that manganese itself is mildly toxic is likewise poorly established to date, because of the possibility of its contamination by more toxic impurities—at least in any work publicly recorded. There seems to be considerable justification for the opinion that the higher oxidized forms of manganese formed during electrolysis—such as permanganate, possibly the manganic sulphate and perhaps the dioxide mud, in conjunction with impurities like cobalt or antimony—are harmful. They cause re-solution of the cathode. The question, if settled, will probably demand more experimental work with diaphragm cells, in order that higher oxidized forms of manganese can be segregated from the catholyte.

When a zinc-sulphate solution containing manganese sulphate is placed in an electrolytic cell with a lead anode or a peroxidized lead anode, and a direct current is applied, a film of pink solution forms immediately around the anode, the pink being the familiar permanganate color. This spreads through the solution, which darkens both by accumulation of the permanganate and by formation of manganese dioxide, caused by reaction of the permanganate with manganous sulphate and other reducing agents. The electrolysis of zinc-sulphate solution produces zinc, sulphuric acid, and oxygen, according to the equation: $ZnSO_4 + H_2O = Zn + H_2SO_4 + \frac{1}{2}O_2$. The oxygen at the moment of liberation is atomic oxygen, which unites easily with any oxidizable substance. If any manganous ion can diffuse to the proximity of the surface where atomic oxygen is forming, it can be oxidized from its bivalent manganous state to the tetravalent manganic or to the heptavalent permanganic state. The discharge of the SO_4 ion at the anode is called the primary reaction. Its union with water to form sulphuric acid and oxygen is a secondary reaction, and the oxidation of manganous ion to permanganate ion is a tertiary reaction. It is therefore not surprising to see formation of manganese dioxide by interaction of the permanganate with manganous ion, taking place to some extent throughout the entire solution, though mainly localized to the immediate neighborhood of the anodes. The loosely adherent manganese-dioxide scale is probably the result of this chain of reactions. Direct oxidation of manganous sulphate to manganic sulphate, and hydrolysis with formation of sulphuric acid and manganese dioxide, is another possible explanation, but the permanganate color, usually visible, favors the first theory.

Polarization of an insoluble anode may be conceived as the accumulation of atomic or molecular oxygen in a film and in gas bubbles on the

The first part of this article appeared in the issue of Oct. 23.

anode surface, increasing the resistance to the passage of an electrical current, and therefore expressed by an increase in the necessary driving voltage required to pass a definite current between the solution and the anode. Depolarization means provision of some agent in the solution to combine with this oxygen as fast as it forms at the anode, thus preventing the atomic oxygen from uniting into less active molecular oxygen. This would mean cutting down the film of oxygen, and with it the necessary operating voltage of the cell. Depolarization is expressed by this drop in voltage. Manganous sulphate in the solution can function as an acceptor of atomic oxygen, being oxidized either to the manganic or to the permanganic state.

What reaction will occur and the rate at which it proceeds depends on the composition of the anode surface, whether it be smooth, fresh metallic lead, spongy lead, lead peroxide, or manganese dioxide. All of these surfaces are likely to be present, and varying behavior may be expected. This phase of the subject, not brought out in the trial, should be clarified.

It is frequently stated that fresh lead anodes placed in a solution containing manganous sulphate tend to strip out manganese as the dioxide much more efficiently than do electrodes with a heavy coating of manganese dioxide. As the anode acquires a deeper scale of manganese dioxide it is less and less efficiently depolarized by the manganous sulphate. The cause of this decrease in depolarizing efficiency is a matter of conjecture. I am told by U. C. Tainton that in practice he has suffered the same experience at the East St. Louis plant of the Evans-Wallower Zinc Company, where an attempt at manganese dioxide recovery is being made. At that plant the anodes reach a steady condition in about three weeks. Periodical stripping of manganese from solutions by use of fresh lead anodes is also practiced at Risdon, in order to keep manganese below 15 grams per liter. Depolarization is therefore to be regarded as a function of the previous history of the anode.

In general practice the final steady condition of the anode, attainable in about three weeks, is the average condition prevailing. Anodes, cleaned only every three to six months in most of the plants, are therefore usually operating under a maximum thickness of manganese-dioxide scale. This makes them manganese-dioxide electrodes instead of lead electrodes, except as qualified later in this paper. Little mention is to be found in anything published before this lawsuit of the voltages prevailing in zinc-sulphate solutions with and without manganese. The testimony of the expert witnesses about actual voltages observed under various conditions will therefore be of interest in judging depolarization.

The witness W. E. Harris, in the seventeen-hour test described previously, reported the voltage in the solution without manganese to be 3.29 to 3.35 volts in check tests. When identical solution was used containing 0.193 per cent Mn (1.93 grams Mn per liter), the voltage of the cell was 3.37 volts. The difference is in the wrong direction, according to Mr. French's claim, but is so slight that it may be disregarded for practical purposes.

In the Harris three-hour test the voltage in works solutions containing manganese in unknown, but definite amount was 3.66. In synthetic solution under otherwise identical conditions it was 4.61. Addition of more manganese to the works solution lowered the voltage still further, although Harris did not comment on the drop in cell voltage from decreased cell resistance resulting from the presence of more electrolyte. Insufficient data were presented to permit any understanding of how an acidified zinc-sulphate solution could show a voltage drop of 4.61 under any of the usual commercial conditions. This voltage means either very high current density, very low acidity, or wide spacing of the electrodes. Being at variance with all usual practical data, it must be discarded as without meaning.

As an interesting comment on judicial procedure, the only really authoritative piece of literature on anodic deposition of manganese dioxide from manganous-sulphate solutions—the paper by G. D. Van Arsdale and C. G. Maier, *Transactions* of the American Electrochemical Society, Vol. 33, 1918—was excluded as evidence on the ground that the reference had not been included in the pleadings preliminary to the trial.

C. S. Witherell, the witness whose experiments with and without manganese in the solutions are described in connection with the cathode effect, observed almost identical voltages in the two cells, seemingly indicating no depolarization. He was therefore unable to support French on this point.

Witness Harry Hey agreed that depolarization of the anode by manganous sulphate would mean lowering of the voltage, less evolution of oxygen, and large proportional precipitation of manganese dioxide, the theoretical amount for 100 per cent depolarization being 1.3 tons per ton of zinc deposited. Actually, this does not take place. The voltage is not perceptibly changed; oxygen evolution is not noticeably altered; the precipitation at Risdon is only 1.25 per cent of the above theoretical amount. This latter figure was checked by witness S. G. Blaylock, of Trail, B. C., who stated that the anodic current efficiency in manganese precipitation at Trail was only 1 per cent. The remaining 99 per cent of the oxygen at the anode escapes, or is available for attacking lead. Depolarization and lower voltage mean high anodic efficiency.

Blaylock also stated that no perceptible difference in voltage was noticeable between cells operating on solutions containing manganese and solutions with no manganese. However, if the accumulation of manganese-dioxide scale on an anode becomes very thick, the voltage of the cell is higher, probably because of the lower electrical conductivity of the scale. Therefore, the facts in this case are the reverse of the claims of A. G. French. Hey pointed out that only one set of conditions was observed by him where a definite difference in potential across cells exists with and without manganese in the solutions. In this case, solutions containing less than 2 per cent acid, and thence falling within French's specifications, show a slightly higher voltage when containing manganese.

My own experience is that, when anodes are covered with a thick scale of manganese dioxide, the cell voltage is 0.10 to 0.25 volts higher than it is immediately after cleaning off what scale may be easily removed. This agrees with Blaylock's statement. Only anodes over a month old show this difference.

Summarizing, therefore, the claim of depolarization at the anode was almost totally unsubstantiated. The actual average anodic current efficiencies in precipitating manganese were shown to be only slightly over 1 per cent. Only with clean, fresh lead anodes can higher efficiencies be attained. The lead anodes lose this efficiency rapidly as the manganese scale accumulates. In his experimental work, A. G. French may have noticed heavy precipitation of manganese dioxide on his fresh lead anodes, and concluded that the polarization was always efficient. He did not know nor specify that, to maintain anode efficiency, the anodes would probably have to be stripped periodically, as do the cathodes. Those who might have followed his directions would have met with disappointment. The story told by the voltages, likewise, does not confirm the claim of depolarization. Permanganate and manganese dioxide are observed in apparent quantities in the cells, but without efficient depolarization. Probably more manganese is actually being precipitated than corresponds to the unmeasurable voltage drop. Apparently some of the oxygen escaping into the solution is active and precipitates manganese without reducing the voltage. Perhaps some of the oxygen leaves the anode as ozone, and this is the active oxygen in question. The smell of ozone is perceptible around freshly started cells. All these reactions need scientific investigation.

A coating of manganese dioxide over the lead anode should help to protect it from attack by the electrolyte. Yet, some of the evidence to the contrary is of interest.

Prior to the French patents, lead anodes had been looked upon with little

favor. In sulphate solutions they were known to corrode rapidly, being converted mainly into lead peroxide, which formed first as a scale and later dropped to the bottom of the cell. The true mechanism of rapid anodic corrosion of lead was discovered not by the electrolytic zinc men but by the electrolytic copper operators. The problem came to a head at Chuquicamata, where Witherell was once operating superintendent. He brought out none of this in his testimony, but the fact is, nevertheless, that the copper ore in question contains considerable chlorides and nitrates. Lead anodes cannot be used in electrolyzing copper sulphate solutions with these contaminants present. Presence of chlorides having been established as one of the principal causes of lead anode corrosion, the electrolytic zinc men looked for and found chlorides in the solutions causing most rapid lead corrosion. The plant where this occurred in an aggravated degree was that at Risdon, Tasmania, where witness Hey is chief metallurgist. By keeping chlorine below 0.05 grams per liter, the corrosion is minimized and long life attained, three years or more. Most of these facts did not appear in the testimony, but they are stated here to give the background for the picture of the anode situation at the time when French took out his patent.

Apparently without realizing that the chloride content of the solution was the cause, Siemens & Halske had spent many years developing special lead - peroxide and manganese - dioxide anodes for zinc sulphate electrolysis, and a voluminous patent literature grew up. All this happened in the ten years previous to the French patent, and advertised the anode problem well. Such an obvious solution as preventing the attack by a coating of manganese-dioxide scale could have looked like a long-needed invention. It had long been known that manganese deposited anodically from the zinc sulphate electrolytes, but no definite value of the phenomenon had been realized. This deposition was a natural consequence of the almost invariable presence of manganese in the solution, but French thought he had discovered actual advantages of its presence and sought to patent it. In effect, this was an attempt to patent a law of nature. Had French found special advantages in certain concentrations of manganese, or how to make it deposit in a better and denser form, he would have been exercising a degree of control by means of a natural law, and should have received a valid patent. However, the company exploiting his patent was trying to show that any manganese content was an advantage, and that no limits of concentration existed. Therefore, in their effort to obtain a wide-reaching monopoly, they claimed more than patent law can allow. Whether an advantage exists in practice from manganese will now be discussed.

S. O. Cowper - Coles testified that he had observed manganese dioxide in the anode scale on lead anodes in 1895-99. He had not observed anode life nor the effect of manganese on this question. Witness E. A. Ashcroft in 1896-98 had electrolyzed solutions with about 100 grams zinc and 10 grams manganese per liter, and had produced plenty of manganese-dioxide scale on his anodes, but had not operated long enough to notice the effect of manganese on the life of the anodes.

S. Laszczynski testified that he had tried to prevent oxidation of manganese by wrapping the anodes with fabric. He failed to prevent the manganous ion diffusing through the fabric to the anode, and consequently always formed manganese-dioxide scale, even though the diaphragm prevented coloration by permanganate of the electrolyte outside the fabric. No attention was given to life of anodes.

Witness Victor Englehardt, of Siemens & Halske, had noted the short life of lead anodes in zinc sulphate solutions—even those containing manganese. Not knowing all the causes of corrosion, and ascribing the trouble to the intrinsically poor resistance of lead, he had sought a better anode material, as mentioned in the foregoing, resulting in several German, British, and American patents, in the names of himself, his subordinates, and his firm. He had sought to press, form, or otherwise mold lead peroxide or manganese dioxide into anodes, which could be used instead of the sheet lead, and which he hoped would have longer life. Lead anodes in copper plants of the same period (1900-12) were also frequently known to have short life, in some cases only a few months. Apparently, therefore, French received his impression of short lead-anode life from the numerous publications and patents emanating from the Siemens & Halske group. I doubt if French operated zinc cells long enough to learn first hand of the actual anode life in solutions without manganese, as compared with solutions containing manganese. Observing the heavy scale of manganese dioxide on the anodes, he assumed it was protective.

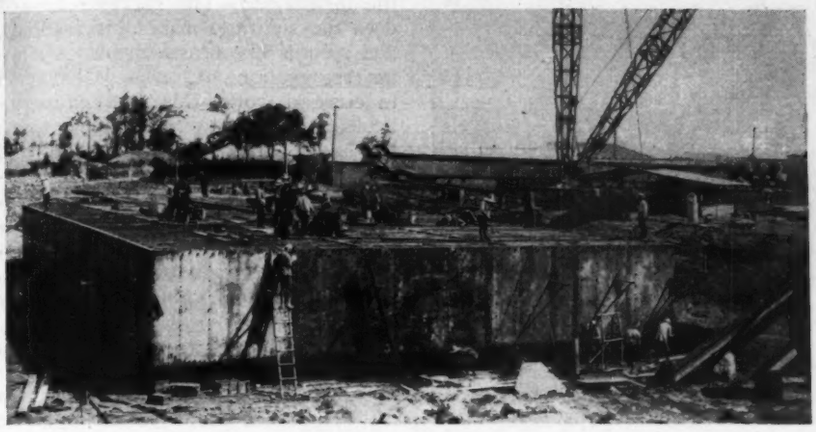
In his testimony, W. E. Harris described the behavior of sheet-lead anodes without manganese protection. At first a coating of lead peroxide forms. This grows thicker, but in a few weeks it curls, becomes non-adherent, and peals off. New lead then peroxidizes, repeating the cycle. With manganese in the solutions, the anode is covered with manganese dioxide, which binds the first-formed lead peroxide, preventing it from cracking and flaking. Harris' anodes at Llansamlet lasted the full three years' life of the plant. His solutions had averaged only 0.5 gram manganese per liter, and much of it entered the anode scale and sludge.

C. S. Witherell testified that lead anodes in a solution free from manganese would have a life of two or three months, and not to exceed six months. This he based on his experience many years previously in copper-sulphate electrolysis, where presumably the same anode reactions are involved. His figure, probably true in the days when he was an operating superintendent in copper refineries, was contradicted later in the trial by R. B. Caples, who had wired for the figure on lead-anode life in the copper refinery at Great Falls. The life in copper solutions free from manganese was reported to be 1.5 to 2.0 years, the anodes actually losing 10 per cent in weight per year. Presumably this improvement in the life of lead anodes in copper refineries is due to better control of the solutions, especially preventing contamination with chlorides. Witherell said that a clean lead anode first became coated with lead peroxide, then with manganese dioxide, after which it was to some extent protected from attack by the solution. The outer surface of the manganese - dioxide coating was the place where most of the oxygen was generated. Destruction of the lead anodes is not entirely prevented, but the attack is minimized.

Harry Hey said in his testimony that the manganese-dioxide scale does not include the cobalt of the solution, and in this he was supported by Harris, Clevenger, and Caples. Cobalt does not accompany manganese dioxide into the anode precipitate in acid solutions. It is carried down by manganese dioxide precipitated in neutral or basic solutions, as mentioned earlier. Therefore, the continued electrolysis of solutions containing cobalt and manganese leads to no purification from cobalt and is of no benefit to cathode deposition. The manganese deposit on the anode is porous, like a sponge, and not dense nor adherent. Oxygen can therefore aways discharge to a certain extent on a surface of lead. Hey felt that oxygen not only reached the surface of the lead but penetrated it, possibly along the intercrystalline boundaries. An anode in use for some time crystallizes, or at least the outlines of its crystals become distinct. Corrosion of the lead continues in spite of the scale of manganese dioxide. This is shown by the continued presence of lead in the manganese anode mud. Most manganese mud contains from 5 to 15 per cent lead as PbO_2, even from old, well coated anodes. The men of the staff at Risdon once thought the manganese-dioxide scale helped to protect the anodes, and are on record with that opinion; but later learned that chlorine was the controlling factor. They then precipitated chlorine with silver. Only 0.05 grams per liter is tolerated.

Japanese Gold-Dredging Enterprise

H. S. Little



Constructing the hull

RECENTLY, near Kintei, Province of Zenrahudo, Korea, the Mitsubishi Kogyo Company, of Japan, constructed and placed in operation a Yuba-type gold dredge. The area to be dredged is about 6,000 acres of an average depth of 20 ft., and it lies in the valley contiguous to the Kintei River. This river has a summer flow of about 1 sec.-ft., but its flood flow is much greater. It is nominally a shallow river about 100 ft. wide. The dredging area is under cultivation for rice.

Bedrock is a granite formation with few irregularities. Very few boulders are present, but some of these are quite large. An 8-ft. clayey layer at the surface is underlain by sand and gravel to bedrock. The gold is usually in the 3-ft. layer immediately above bedrock, and, similar to that in the Hammonton district in California, amalgamates readily.

The area was proved by Japanese engineers, who used Empire hand drills for sampling and exploration. Drill holes were placed at the corners of squares 360 ft. on a side. The ground has been calculated to give a ten-year life to the dredging operations. Conditions are complicated by provisions in the Korean law that necessitate the restoration of the dredged ground for agricultural purposes either during or after dredging.

After proving its ground, the Mitsubishi company secured the services of the Yuba Manufacturing Company, of San Francisco, Calif., to supply the dredge and to give technical assistance in initial operation. A 10-cu.ft. close-connected dredge of the Yuba type, with steel hull, was shipped to Korea. Special equipment for resoiling consisted of two stackers, double chutes on ends of stackers, two sand wheels, and two sand pumps. This equipment was developed in California resoiling operations at Natoma. The dredge was shipped dismantled, so that erection involved the building up of all major parts, such as digging ladder, stacking ladders, and other heavy pieces.

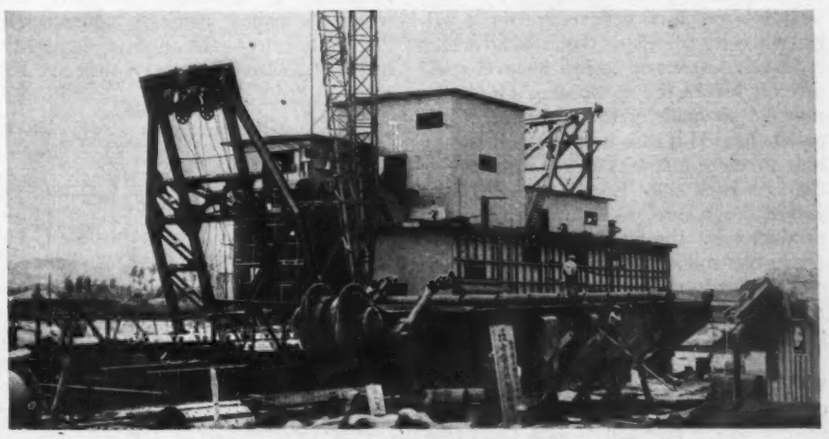
Hull width is 56 ft.; depth, 10 ft.; length, 130 ft. Special Yuba alloy is used for pumps. Buckets are of manganese steel; lower tumbler is of manganese steel, and upper tumbler of one-piece construction with manganese-steel liners.

Electrical equipment on the dredge was supplied by the Westinghouse company and all other equipment by the Yuba company. Digging depth limit of the dredge is 33 ft. below water level. Pumping equipment comprises a 12-in. high-pressure unit and a 12-in. low-pressure unit, a 6-in. hopper, 4-in. auxiliary unit, two hull pumps, and two 6-in. sand pumps. Steel spuds, shipped knocked down, were assembled on the job. The motor equipment consists of fifteen motors, totaling about 700 hp. Heating equipment included a steam boiler.

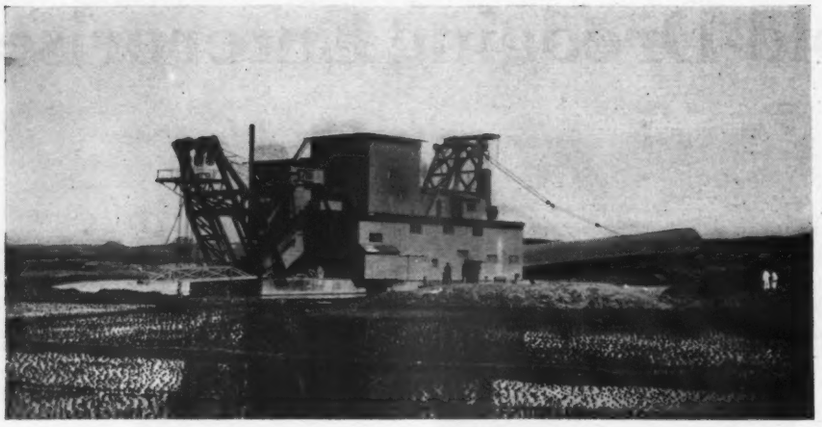
Local contracts were let for transportation and for erection. S. Mayeda was superintendent of construction and M. Sugiyama was manager. I represented the mining company and checked all details of erection.

A pit 200 ft. square and 10 ft. deep was dug by hand, the dirt being carried out on the backs of the workers. The dredge shipments were received at Kunsung and transported to Kintei, 75 miles by rail. From this point most of the equipment was handled by bull teams over a dirt road. The heaviest pieces—the upper tumbler and other parts—were transported on a special car, which was pushed forward on rail sections, the rail sections being moved around to their new position by hand. In this laborious way, two months passed in getting the upper tumbler to the dredge site, a distance of 8 miles. The lower tumbler, screen, bull gear, ladder-hoist winch drum, and all single pieces weighing more than 3,000 lb. were transported in the same manner. Five trips were required. Many small individual contracts were made both in the transportation and in erecting different parts of the dredge. In all, eight months was required to place the dredge in operation.

A machine shop was constructed of timber-frame, galvanized corrugated steel. All other quarters were mud houses with galvanized corrugated steel roofs. The power house, placed at Kintei, 8 miles away, supplies alternating current for an 11,000-volt transmission line. The prime mover is a 1,000-hp. Diesel unit of German make. Voltage is stepped down at the dredge substation to 3,300 volts, and transformers on the



Assembling the digging ladder



The dredge in operation in the rice fields

dredge reduce this to 440 volts. Wages ranged from 60 sen (30c.) to a maximum of 2 yen 50 sen ($1.25), and averaged 80 sen (40c.).

The operating crew was trained by Charles Scribner, dredgemaster, of Hammonton, Calif. Two months were required to get into regular operation, as a result of the crew's initial lack of experience. The average yardage has been 7,000 cu.yd. for 22 hours' operating time per day. Application of the resoiling equipment, to a large extent automatic in its operation, has been successful. The resoiled area is about 3 ft. above normal level at the time of dredging, but in the course of a few months subsides to almost its original level. Dredge operation is now entirely in the hands of the Japanese.

The Oriental, with little idea of the value of time, is likely to postpone to the morrow what can be done immediately. He is a leisurely worker, and, within his limitations, a fairly good mechanic. He prefers his own tools, which are usually small and inadequate. The practice of letting many individual contracts seems to be universal and does not involve special difficulties. No system of accounts was maintained, payment being by lump sum.

Many of the limitations imposed by custom are amusing. For example, a Korean surveyor has four assistants: one to hold a sun shade, one to pack around a small table upon which the field computations are made, and the others to chain, drive stakes, and set up the instrument. The surveyor himself does the sighting, makes his readings, and records his measurements. A similar segregation of tasks is common in erection work. Managers, superintendents, and other overmen never touch the handle of the pick or shovel, and only by voice and gestures do they convey instructions. Although erection involved a long time, the job was thoroughly done. The Japanese engineers and overmen understood their work, and assumed operating responsibility effectively.

The total number of employees—in power plant, dredge, office, and on miscellaneous work—approximated 120. On the dredge ten men are employed on each shift, and on the day shift ten men are also employed on bank work. This large number of men on the dredge gave almost one man for each machinery unit. As a result, the dredge machinery received unusual care, and lubrication was effected more conscientiously than upon gold dredges in America. By introducing a weighing system and a bonus system for the use of a small amount of grease, the same efficiency with a saving of 50 per cent of the grease was attained. There were no hot bearings and no burn-outs.

■ ■ ■

Pallet-Leveling Device

A SIMPLE DEVICE for leveling the pallets on a sintering machine as they approach the feed chute has been designed by L. W. Kirk, master mechanic at the Midvale plant of the United States Smelting, Refining & Mining Company, and is in effective service at that smelter, according to F. M. Wichman, plant engineer.

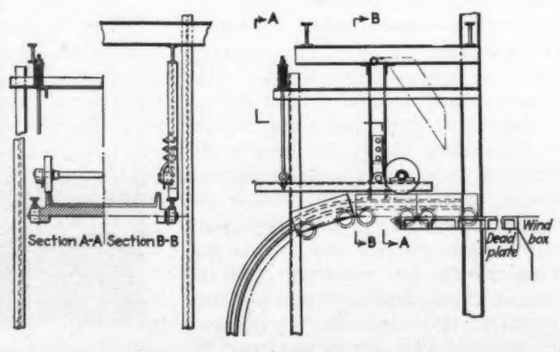
It is a common occurrence for a pallet, when its wheels or the rails on which it travels are worn, to fail to level itself after it leaves the sprockets. The pallet may be so held by the pressure of the pallets behind it that its front end is one-half to three-quarters of an inch higher than its back end. Eventually it will be jarred down into place by the vibration produced by the pallets falling at the discharge end of the machine, but often not until after the pallet has received its charge and passed over the dead plate.

If the pallet receives its charge while it is held in an inclined position, fine ore or concentrate will settle into the V-shaped space between it and the pallet ahead, thus preventing close contact of the two pallets. Then if the pallet settles down after the charge has ignited a crack is likely to form in the charge.

If the pallet passes over the dead plate in an inclined position there will be considerable air leakage at that particular point.

The pallet oiling system in use on the machines at Midvale functions only when the pallets come in contact with the rails after the pallets leave the sprockets. Consequently, if they are held off the rails, they do not receive lubrication.

The Kirk device is shown in the accompanying illustrations, which require no further explanation. The springs, which do most of the work, may be adjusted for any desired tension by means of the rods passing through them. Tension exerted by the springs, acting through the cast-iron disks, which roll on the flanges of the pallets, forces the pallets down onto the rails.



Details of device for leveling sintering machine pallet

Metallurgical Filing System

S. E. Stein

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THE metallurgical filing system outlined herewith is based on a mechanical classification rather than an alphabetical one or one involving the names of specific equipment or of manufacturers. It is merely an outline, but an outline that permits extension of any of the sections as required. It covers methods, costs, and equipment. Where feasible, the price data are filed with equipment data, or the price data are filed under Class Y. Equipment catalogs, blueprints of drawings, and photographs can be filed in individual parallel filing systems.

A–100 Patents (non-flotation)

B–100 Crushing, coarse
B–200 Crushing, intermediate
B–300 Grinding, intermediate (wet)
B–400 Grinding, fine (wet)
B–500 Grinding (dry)

C–100 Classification (wet)
C–200 Classification (dry)

D–100 Screening (wet and dry)

E–100 Concentration, gravity (dry)
E–200 **Concentration, Gravity (wet)**
E–201 Jigging
E–202 Tabling
E–203 Vanning
E–204 Centrifuging
E–205 Miscellaneous
E–206 Flow sheets
E–300 **Concentration, flotation**
E–301 Equipment, description of
E–302 Methods, description of (general and detail)
E–303 Patents on equipment, methods, and reagents
E–304 Reagents (combine specific and general at start)
E–305 Flow sheets (general)
E–306 Research and theory
E–307 Non-metallics (such as phosphates, mica)
E–308 Metal-oxides (lead carbonate, copper silicate)
E–309 Metals and sulphides
E–310 Substances (oils and chemicals)
E–311 Miscellaneous (but do not separate bulk and selective flotation here or elsewhere; note that flotation is classified only into legal, equipment, methods, materials used, substances treated, and theory)
E–312 Plant operating results, single and comparative

F– — **Dewatering (of divided solids)**
F–100 Thickening (cones and thickeners)
F–200 Filtering
F–300 Drying
F–400 Miscellaneous

G– — **Plants (non-smelting) complete, of particular companies, descriptions of**
G–100 Crushing, screening, and washing plants
G–200 Gravity concentration plants (having no flotation)
G–300 Flotation plants (complete or flotation department only)
G–400 Industrial plants, miscellaneous
G–500 Leaching plants (non-cyanide)
G–600 Cyanide plants
G–700 Miscellaneous complete plants

H– — **Ore beneficiation (other than flotation and gravity)**
H–100 Leaching (non-cyanide)
H–200 Cyanidation
H–300 Chemical, miscellaneous
H–400 Amalgamation
H–500 Complex combinations
H–600 Mine waters, beneficiation of (copper)
H–700 Magnetic and electrostatic separation
H–800 Miscellaneous

I– — **Transportation of liquids, solids, and pulps**
I–100 Conveyors, incline, shuttle
I–200 Elevators
I–300 Pipe lines, steel and wood-stave
I–400 Dust transporting and collecting systems
I–500 Centrifugal pumps
I–600 Diaphragm pumps
I–700 Pumps, other than I-500 and I-600
I–800 Trams, aërial
I–900 Cars, rail (electric, steam, gas, and cable)
I–1000 Electric cranes
I–1100 Excavators and shovels
I–1200 Miscellaneous.
I–1300 Launders and sluices
I–1400 Hoists

J– — **Storage of liquids, solids, and pulps**
J–100 Ore bins, wood
J–200 Ore bins, steel
J–300 Storage tanks for wet pulps
J–400 Receiving tubs, surge boxes, and tanks
J–500 Sumps
J–600 Miscellaneous

K– — **Sampling**
K–100 Solids samplers
K–200 Wet pulp samplers
K–300 Liquids samplers
K–400 Mill sampling systems and arrangements
K–500 Sampling laboratory arrangement, general
K–600 Sampling laboratory equipment
K–700 Sample records
K–800 Miscellaneous

L– — **Feeding**
L–100 Dry ore feeders
L–200 Wet pulps, miscellaneous (not listed under "transportation" or "storage")
L–300 Liquid reagent feeders
L–400 Solid reagent feeders
L–500 Miscellaneous

M– — **Millsites and mills, general**
M–100 Ore supply
M–200 Water supply
M–300 Concentrate disposal (handling from filter)
M–400 Tailing disposal
M–500 Excavation and foundations
M–600 Miscellaneous
M–700 Shops (machine, blacksmith, foundry, electric)
M–800 Office, warehouse, laboratory
M–900 Townsite, residences, sanitation, recreation

N– — **Mill housing and mills, general**
N–100 General flow sheets
N–200 Grouping of equipment and departments
N–300 Mill housing in tropics
N–400 Mill housing in cold countries
N–500 Mill-house lighting, electrical and miscellaneous
N–600 Mill-house heating
N–700 Fire protection and insurance
N–800 Miscellaneous

O– — **Air**
O–100 Compressors (high-pressure)
O–200 Low-pressure blowers, Roots and Connersville types
O–300 Low-pressure blowers, centrifugal
O–400 Blowers, miscellaneous
O–500 Vacuum pumps
O–600 Vacuum systems (non-dust collecting)
O–700 Miscellaneous
O–800 Air drills and hammers
O–900 Air conditioning and dust control

P– — **Metallurgical control and experiment**
P–100 Assay laboratory and equipment
P–200 Chemical analysis, methods of
P–300 Miscellaneous general chemistry and physics
P–400 Smelter settlement schedules
P–500 Formulas of metallurgical control in mill, and measurement of actual performance
P–600 Plant experiment, methods and control
P–700 Laboratory testing equipment
P–800 Laboratory testing, general
P–900 Miscellaneous

Q– — **Agitation and mixing of liquids, solids, and pulps**
Q–100 Mechanical agitation for liquids and for wet pulps (Devereux and S.W. agitators)
Q–200 Compressed air agitation for liquids and for wet pulps (Pachuca type)
Q–300 Miscellaneous methods of agitation for liquids and for wet pulps (Dorr agitators, use of flotation machines)
Q–400 Mechanical mixing of divided dry solids
Q–500 Mechanical mixing of solids and liquids (concrete mixers)
Q–600 Miscellaneous

R– — **Disintegration, dispersion, and flocculation (of liquids, solids, and pulps)**
R–100 Disintegration of coarse organic solids
R–200 Mechanical deflocculation (colloid grinders)
R–300 Mechanical flocculations, jelling
R–400 Chemical flocculation and deflocculation
R–500 Miscellaneous

S– — **Mill design and engineering**
S–100 Engineering department organization
S–200 Plant layouts, general and miscellaneous
S–300 Standards
S–400 Specifications
S–500 Equipment and supplies
S–600 Miscellaneous

T– — **Smelting and refining**
T–100 Plants, complete, of particular companies, description
T–101 Lead smelters
T–102 Copper smelters
T–103 Zinc smelters and refineries
T–104 Copper refineries
T–105 Nickel, antimony, mercury, arsenic, tin, tungsten
T–106 Ferrous metals
T–107 Miscellaneous
T–200 **(Theory and practice)**
T–201 Ferrous metals
T–202 Copper
T–203 Lead
T–204 Zinc
T–205 Miscellaneous metals
T–206 Miscellaneous salts and chemicals
T–300 **(Special Processes)**
T–301 Chloridizing roasting, Dern's process
T–302 Miscellaneous
T–400 **Roasting, general**
T–500 **Converting, general**
T–600 **Furnaces, general**

U– — **Gases, production, condensation, and heat exchange**
U–100 Heat exchangers, coolers, and condensers
U–200 Stills
U–300 Fractionators
U–400 Absorbers
U–500 Miscellaneous

V– — **Shipping data**
V–100 Rail, water and air transportation
V–200 Hauling, handling, and storage
V–300 Duty, tax, and insurance
V–400 Miscellaneous

W– — **Mining**
W–100 Geology
W–200 Mining methods
W–300 Prospecting, drilling
W–400 Geophysical prospecting
W–500 Mine sampling
W–600 Mines (description of)
W–700 Mineralogy
W–800 Production and market statistics (of ores, minerals, metals, and concentrates)
W–900 Miscellaneous
W–1000 Mining law

X– — **Installation and operation costs**
X–100 Plant installation cost records
X–200 Plant installation cost estimates
X–300 Plant operating cost records
X–400 Plant operating cost estimates
X–500 General
X–600 Miscellaneous

Y– — **Power generation**
Y–100 Water power, turbines, Pelton wheels
Y–200 Steam power, engines, turbines, boilers
Y–300 Internal combustion engine power (non-Diesel)
Y–400 Internal combustion engine power (Diesel)
Y–500 Electric power generators, batteries
Y–600 Miscellaneous

Z– — **Power transmission**
Z–100 (Electrical) transmission lines, wiring
Z–200 (Electrical) substations, transformers
Z–300 (Electrical) motors
Z–400 (Electrical) accessories
Z–500 (Electrical) miscellaneous
Z–700 (Mechanical) shafting, bearings, hangers
Z–800 (Mechanical) pulleys, gears, clutches, couplings, idlers
Z–900 (Mechanical) belting, chains, rope
Z–1000 (Mechanical) complete short-center drives
Z–1100 (Mechanical) speed-transformers
Z–1200 (Mechanical) miscellaneous

AA– — **Prices and costs, miscellaneous and general**

BB– — **Miscellaneous and general**

Top-Slicing in the Southwest

Morris J. Elsing

Mining Engineer and Geologist,
Tucson, Ariz.

THE top-slicing method of stoping was first introduced into the Southwest in a large way at Cananea in 1907. During a shutdown, in which a complete renewal and renovation of milling, power, and smelting equipment was under way, a number of foremen and shift bosses were sent to the Michigan iron mines to make a study of top-slicing as practiced there. They returned to Cananea with great enthusiasm as to the possibilities of applying this method to the soft-ore mines of the camp. This was very successfully done. In all of the old square-set mines, top-slicing was employed, and the main production of the camp was made from these stopes. Since its inception it has been the most important method of mining at Cananea. It was used at the Capote, Oversight, Veta Grande, Kirk, Cobre Grande, Sierra de Cobre, and Campana mines. Its use, of course, has varied and has always been governed by ore conditions. At present, the production is less than it has been for twenty years, but the method is held in high regard, and it will become more important in the future.

After top-slicing was introduced at Cananea it was rather extensively used in the Southwest. However, its most important application was at Miami and in the Morenci-Metcalf district. At Miami, a large area of ore running over 2 per cent copper was mined by a modification of slicing known as the "block" method. Top-slicing there has not been used since 1919, although some remarkably low mining costs were obtained.

In the Morenci-Metcalf district, top-slicing was a very important method for many years. In the latter half of 1916 an innovation was devised in top-slicing to eliminate shoveling. This consisted of top-slicing on the incline rather than with horizontal floors.

Much has been written about top-slicing, but in all of the published literature certain of its phases have not been discussed and other phases have not been sufficiently emphasized. Top-slicing at Cananea has been used continuously for more than twenty years and a more or less standard layout of stopes has been developed which is not generally used in the Southwest.

Reference to Figs. 1 and 2 will facilitate an understanding of the Cananea method. Its principal difference from other methods lies in the fact that it always provides at least one standard two-compartment raise in the waste wall. This is usually located at the end of the orebody, but it may be at almost any convenient point. Its position is determined by several factors, among which are convenience to haulage facilities on the level above and character of ground.

The general outline of the method of working of such a stope is as follows: The top 20 or 30 ft. is mined by square-sets, which are filled. The purpose of the square-sets is dual, in that they take care of the irregularities of the top of the orebody, and—what is very important—provide a cushion above the slice timbers. In all cases where slicing is used, it is necessary to break the back over the stope so that it will follow down as slicing proceeds. In general, top-slicing is confined to soft ores, which are often capped by soft ground, under which conditions no difficulty is had in making the back follow the slice down. Cases do occur where it becomes necessary to enter an opening above a top-slice and make it cave. When 30 or more feet of waste rest on the timbers of the slice there is not much danger of a cave seriously affecting the slice. It is well cushioned and the shock of a fall, save in exceptional instances, is not registered on the timbers below.

ASSUME that the portion of the orebody above the 100 level has been mined by square-sets and that these have been filled. Slicing will start immediately below the 100 level. Small two-compartment cribbed raises are driven from the 200 level up to the 100 level. These raises are used as ore chutes and should be spaced at from 30- to 50-ft. intervals, depending upon whether they are to be filled by shoveling, wheelbarrows, cars, or scrapers.

The important feature of the layout is the square-set raise in the waste wall, and, as soon as it has been completed, drifting starts from it 11 ft. below the 100 level. This drift is driven through the intervening waste to the orebody and is continued through it, roughly bisecting it. Other conditions being equal, it is well to locate the raise at the end of the orebody. The drift then runs through its longer axis.

Stoping is started at the further end and progresses toward the raise. The raise is the main artery of the stope until it is worked down to within two or three slices of the level below. Entrance to the stope is had from the level above. All timber and supplies are lowered into the stope. Air and water pipe lines are brought down through it. It provides a most excellent means of ventilation for air coming up through the ore chutes to the working faces and passing on to the 100 level. The main subdrift and the raise are the safest means of entrance and exit that can be provided. In short, the raise is the key to the whole operation.

BREAKING of the ore and its delivery to chutes follow the conventional methods. The sections to be mined are laid out in various ways, depending mainly upon the tonnage desired. If only a small tonnage is to be mined, the face of the stope is brought back in one sweep across the orebody. A greater tonnage can be produced by starting additional sections on one or both sides in addition to the end stope. This is the usual practice in top-slicing.

When a slice is mined and completely shot down, the first operation is to get up into the cribbed raises and drive a new longitudinal drift under the floor. This drift is started from several raises at the same time so as to connect it with the main raise as soon as possible. A new drift in the waste is not driven on each floor. As indicated in Fig. 1, a short incline is run, connecting the lower drift with the waste drift above. One drift from the raise usually serves for two or three slices. This serves all purposes of the original drift on the floor above and does away with the necessity of doing the extra drifting in waste on each floor.

Drifting from the cribbed raises is confined to the completing of the longitudinal drift. When this work is being done from these raises, the ventilation is poor, and the drifts are usually warm. Timbers are hoisted from the level below. In general, working conditions are not as good as when the main slice drift is completed through to the square-set raise. After this has been done, the air course is established and the transverse drifts are started.

This is the second of a series of articles by Mr. Elsing, discussing standard mining methods. The first was entitled "Square-Set Stoping."

Slicing as developed in Cananea is somewhat different in another respect from the top-slice stopes that I have seen in other parts of the Southwest. In other camps, according to my own observations and according to top-slicing literature, it is customary to shoot down small sections of a stope. In describing some operations the literature explicitly states the dimensions of a narrow panel and that when it attains this width it is immediately shot down and a new one started.

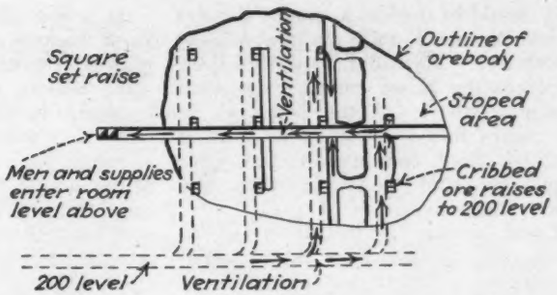


Fig. 2—Plan of a top-slice stope

In Cananea, the practice is entirely the reverse of that detailed in the preceding paragraph. Stopes are usually allowed to remain open as long as they will. In operations conducted in soft, heavy ground I have seen the stulls actually forced down into the ore below and the whole floor above uniformly sink on to the newly laid floor. When the back is following down as it should, there is absolutely no danger in allowing a large floor to remain open almost as long as it will. Of course, no attempt is made to keep a floor open by putting in extra timber. It is certainly an advantage to shoot down a large floor, in that it disturbs the floor timber above less than when small sections are shot down. Usually, hours before it comes down there is plenty of warning. Timbers creak and snap, and occasionally give off a report like a gun. The ground overhead begins showing signs of movement, and this is usually the warning that it is time to shoot down the stope.

Experience at Cananea has shown that less trouble is encountered when stopes are allowed to become large, and I think that there is a plausible explanation why this should be so. Suppose a large stope is shot down. A sudden settling of the ground takes place. It drops on the new floor and in a short time packs and becomes more or less consolidated. The new floor is not started until the readjustments of the ground above have taken place. In extreme cases several days might elapse before all movement has ceased. There is a certain amount of interlocking and wedging of large blocks, boulders, and finer material. After this occurs, the material over the stope tends to arch and in a large measure to be supported by the adjacent country. The slice timbers are capable of supporting only a comparatively small amount of the ground overhead which has been broken and is moving. When this ground starts settling, there is no stopping it and no object in attempting to do so. On the other hand, the ground should be encouraged to come so that it can reestablish its equilibrium on the new floor above the ore in place where it can do no damage.

This characteristic of arching above the stope must depend upon many conditions about which we know little and have studied little. The character of material caved must have a marked effect, as well as the faulting and general shearing that may exist. Some materials might form strong, comparatively flat arches, in which case the weight to be supported by the timbers would be the least. Also, the amount of rainfall and the water entering the caved area would have its effect; and, in addition, the width of the stoped area and the character of its walls would have characteristic effects. All of these factors are decidedly problematic, but they certainly deserve consideration.

In working in a caved, broken area the work must be done most carefully, so as to disturb the country above as little as possible, until the conditions are met by placing timber, bulkhead, or gob. If the key pieces are broken and drop out, the whole weight drops. Mining engineers recognize this as one of the first principles of mining.

In top-slicing there is an arching of the overburden above a slice stope, but I doubt that the importance of such a condition has been generally recognized in working with this method. Otherwise, small panels would not be shot down. Such a procedure, if it does not actually break the arch, tends to do so. The repeated shooting down of small sections of the stope every few days is bound to have the effect of loosening key pieces. The area above is constantly kept stirred up, so to speak. It seldom comes to complete rest. If as large an area as possible is mined out at one time, and then shot down, the whole area above comes down with much more force than would be the case if it came in small sections. The result is that the waste and timber mat become more consolidated and will arch more effectively than when the country is continuously kept agitated by repeated caving of small areas.

I offer this explanation for consideration. To me it seems perfectly logical. As a visitor to various top-slice stopes in the Southwest I have never seen stopes anywhere that worked so smoothly and so consistently without trouble as at Cananea. I have always attributed this to the general methods used, both as to the entrance from the top and the general scheme for working, as well as to the attempt to keep stopes open as long as possible.

This method was successfully used in hard ore as well as soft. There was a wide variation in its application, but the results were in general the same.

To illustrate the heavy ground conditions under which the method was applied, it can be said that in some instances there was difficulty in keeping ore raises open from the level below. The weight of the overburden was transmitted to the ore in place to such an extent that the cribbed raises took great weight. The cribbing would often break, but such an ore chute could be used for a surprisingly long period. At times the chute would have to be abandoned temporarily, and the man-

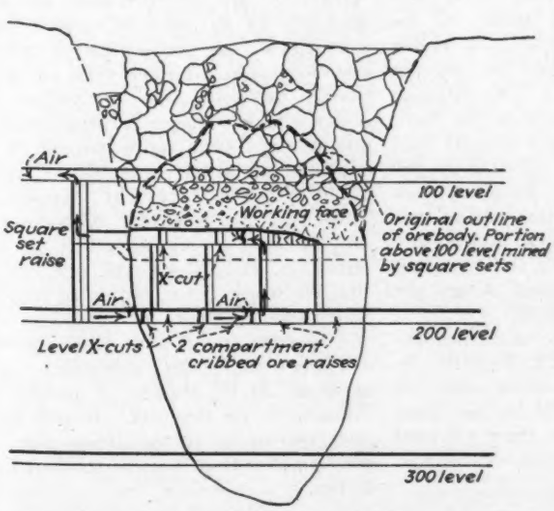


Fig. 1—Longitudinal section of typical Cananea top-slice stope. Arrows show the direction of ventilating currents of air.

way would be used as a chute. Repairs would be made only when absolutely necessary. This did not, however, apply to the raises entering the main gangway above, as the manways in the raises had to be used in starting each new floor, and therefore they were kept in better condition than the chutes themselves.

Level haulage drifts 30 or 40 ft. below the top-slice floor would sometimes take great weight and have to be retimbered. These facts are mentioned to show that top-slicing was not done under entirely ideal conditions. The ground in such instances was as heavy as any that I have seen anywhere; but even in these cases top-slice stopes would be kept open as long as they would stand by themselves. Naturally, in such ground, stopes were brought down more frequently than in hard ground, but the same general rule governed the dropping of floors.

Certain objections have been made to the top-slice stope. A common one is that it does not lend itself to sorting. This is probably true if only small panels are kept open. When large floors are kept open there is ample room to store waste sorted out of the ore. In such a case there is no more difficulty in sorting and storing waste than in a square-set or a cut-and-fill stope. In most stopes where sorting is practiced, certain precautions are required. If waste is sorted out in a top slice it must not be left in such a place that the next shooting of ore will partly fall on it. If this be done, ore will be lost in the sorted waste. It is easy enough to nail a few planks on the stulls in front of the waste pile, which barrier will eliminate any admixture. Sorting is entirely a matter of the insistence of the shift boss. The conditions permitting sorting certainly exist in a top-slice stope.

Fighting mine fires is an extremely difficult task. However, even considering the amount of timber involved, I would rather fight a fire in a top-slice stope than in a square-set stope. Timber in a top-slice is usually confined to a very small vertical extent. The mat is seldom over 10 to 20 ft. thick. In other words, the fire is confined to a definitely known area and at a definite elevation. If it once starts over a slice it is quite likely to spread over the whole of it, but the location of the fire is never in doubt. It might be said that the fire is confined to a two-dimensional plane. Timber raises, of course, burn out from the slice to the level, but even at that it is not like a fire in an old square-set area. Put out a fire in a square-set area and it breaks out in another place. It seems extremely difficult to confine it and extremely difficult to get at it at a vulnerable point, because it is impossible to tell how far it has burned into old stopes on levels above and where it will break out next.

In a top slice, combustion is more rapid because of the great concentration of timber in the mat. For the same reason, it is more likely to be complete, in which case the fire burns out. In square-sets the fire may smoulder for years. Actually there may be no active fire in such a case, because of lack of sufficient air to support combustion. Resumption of work near one of these old fires may start it again by admitting air. The rock is actually so hot that it will ignite the old timber in the sets if air gains admittance.

Top-slice stopes at Cananea have had their share of fires. Most of these originated from fires in old square-set areas with which these top-slices were connected, and at one time a number of incendiary fires occurred which were not confined to stopes alone. Suffice it to say, the fires in the top-slice stopes were extinguished with no great difficulty, mainly because the point where they were burning was known and effective means of attacking the fires could be employed.

If a top-slice stope be laid out properly, ventilation can be made perfect with small expense. Fig. 1 illustrates the direction of the air currents. In fact, the ventilation problem is very simple. The air comes up the ore raises, passes through the working section of the stope and through the main slice drift, and then up the vertical raise to the level above. Naturally, all of the ore raises are not open at the same time, but only those near the part of the area being worked. This gives fresh air at the working face, and, as stoping progresses, the farther raises are covered with the mat and other raises are uncovered, giving air just where desired. There is only a very brief period in the operation of the stope when ventilation is difficult, and that is when each new longitudinal drift is being opened. This operation lasts only for a few days, or until connections are completed, when the ventilating system again operates.

Cost of mining by top-slicing is a big subject in itself. Suffice it to say that complete stoping costs at the Coronado mine, at Metcalf, by incline top-slicing, were less than 90c. per ton in the early part of 1917. This included the cost of delivering ore to the haulage chutes. Similar costs a year previous were obtained at Miami by the horizontal slice stopes. The latter costs included hoisting, pumping, and all underground expense. These figures are cited merely to illustrate the fact that low costs can be obtained where the method is properly applied.

United States Bureau of Mines Information Circular 6325, recently issued, shows total top-slicing costs on the Mesabi range at $1.16 per long ton. On the basis of the short ton used in the Southwest, the details of the cost are as follows:

Mining	$0.65
Transportation (underground)	0.11
General underground expense	0.22
Surface expense	0.06
Total	$1.04

This is truly a remarkable cost when compared to what is being done in the Southwest under somewhat similar ground conditions.

Like all methods of mining, top-slicing has a few disadvantages. The most serious is that it cannot be employed where the effects of caving will result in destruction of the surface which may be of beneficial use. This, however, does not apply to deep orebodies where the vertical ore column is several times smaller than the distance from it to the surface. In such a circumstance the caving effects would not reach the surface.

Another serious objection is that the method cannot be applied unless there is absolutely no chance of its caving unknown orebodies in the immediate vicinity. Where the possibility of such an occurrence is present, a reasonable amount of prospecting should eliminate this objection to its use.

Use of top-slicing in the Southwest has become less and less common. It is entirely logical to conclude that at such mines as Morenci and in the Clifton-Morenci district it has served its purpose in extracting high-grade ores. It is not a low-cost method when compared to the caving methods used at the porphyry mines, and its applicability for mining that type of ore deposit is out of the question. It is, however, a low-cost method when compared with square-setting and most other methods requiring fill.

In Arizona, the use of top-slicing is decreasing. However, in my opinion, it has had a fair trial in only the two camps mentioned and in Cananea. The change in ore conditions at the aforementioned two camps accounts for its disuse there. At Cananea the method is still held in very high regard.

On the other hand, top-slicing in the iron country of Michigan and Minnesota is the most important underground method of mining. Between 4,000,000 and 5,000,000 tons is mined annually by its use. In some respects conditions there are similar to those in the Southwest. I have been an enthusiastic advocate of the method for years and have been surprised that its use has not been more general in the Southwest. It is adaptable to mining such different types of deposits as veins and flat irregular orebodies. It can be used in mining either hard or soft ores, and, in general, one can say that the worse the condition of roof and wall rocks, the more advantageous is its use in comparison with other methods.

Little has been published about methods to be applied in mining the Rhodesian ore deposits. It will be no surprise to me if top-slicing does not play an important part in some of these mines.

Washing Mesabi Iron Ores

Left, Butler Bros. Patrick Unit No. 4, May, 1930, Cooley, Minn. Right, Holman-Cliffs washing plant

BENEFICIATION of iron ore on the Mesabi range by the method of washing began when the Trout Lake plant of the Oliver Iron Mining Company was put into commission in 1910. The development and design of this was the result of experiments carried on by the company during 1905-09 after preliminary work by other individuals on iron ores from the Arcturus and Holman properties had demonstrated the commercial possibilities of washing Mesabi ores. In this plant was initiated what came to be known as the standard Mesabi flow sheet, consisting of a revolving trommel, two 25-ft. log washers, four 18-ft. logs, or turbos as locally termed, and ten to twenty concentrating tables. A flow sheet is shown herewith.

Only during the past six years have any noteworthy deviations from the standard flow sheet been made. The departures have been a consequence of the changing nature of the ores and a tendency toward simplification. On the upper wash ores and on the better grades of the lower wash seam, the standard plant was successful, but in many instances it was found to be less efficient with lean lower wash ore. The lower wash seam often contains coarser sands and finely crystalline quartz adhering to the ore particles. Chunks of ore will contain segregations of silica now disintegrated to fine sand, which can be liberated only by crushing.

Many operators realized that the silica content in the product was gradually increasing. The trommel oversize which, washed under a heavy spray of water, was formerly a satisfactory concentrate, began to analyze too high in silica, owing to the presence of too much material not yet decomposed into ore and sand, and to lumps coated with "frozen silica." The silica elimination in the log washer was probably greater than ever, but too much remained in the washed product. With the leaner wash ores, a greater amount of somewhat coarser silica was found in the tailing of the turbos. This, coupled with the smaller percentage of fine iron, resulted in a less satisfactory table concentrate. The necessity for improving these conditions has resulted in departures from the old system.

Changes found to be necessary comprise principally (1) the replacement of the turbos and tables with bowl classifiers; (2) the introduction of secondary crushing for further liberation of silica from the coarser sizes; and (3) the tendency toward the use of abrasive screening on much of the material formerly treated in the 25-ft. log washers. The two first-mentioned changes have been incorporated in all the new plants as built. The last has several different methods of application and is finding favor among many operators.

Of major importance, the first change to be made in the original Mesabi flow sheet was the introduction of the bowl classifier, to take the entire log-washer overflow, replacing the turbos, chip screens, settling tanks, tables, and concentrate pumps. This classifier had already been developed and widely adopted in Western metallurgical practice, and three of these machines were in use at the babbitt plant of the Mesabi Iron Company.

The first application to the sandy wash ores of the range was made in 1924. An average of sixteen tests, conducted throughout the season, showed that the bowl classifier would recover 8.92 per cent more weight and 15.33 per cent more iron from the log-washer tailing than was possible with the turbos and tables. With the use of the bowl classifier an increased recovery of 3.92 per cent of the weight and 4.35 per cent of the iron units in the crude ore was obtained. The concentrate produced by the bowl classifier was higher both in dry and natural iron, and lower in silica, than the combined concentrate of turbos and tables. The iron assay of the total plant tailing was lowered 4 per cent in consequence. In addition to better metallurgical work accomplished by the bowl classifier, as shown in further detail in Table I, the operation and maintenance costs of one bowl classifier were lower than parallel costs for turbos, tables and auxiliary equipment.

The first season's demonstration of the merits of the bowl classifier resulted in the adoption of the machine throughout the district. At present nearly all the plants on the Mesabi range are equipped with bowls. They have completely replaced the turbos and tables wherever used, with the exception of the Hawkins plant, where turbos are still used to lighten the feed to the bowl classifiers.

Tests made in one plant show that, in terms of crude ore, the amount recovered from high-grade wash ore as classifier product is 11.80 per cent and on low-grade ore 9.13 per cent. At another plant the classifier product is segregated from the rest of the plant concentrate, and shipped separately to the furnaces, where it is sintered. An accurate record of the amount is thus easily kept. In this plant it is found to be about 18 per cent of the total plant product, about 12½ per cent of the crude.

Secondary crushing of trommel oversize is employed to improve the structure of the ore, and further to eliminate

Table I—Comparative Results

	Turbo	Tables	Turbo Plus Tables	Bowl Classifier
Recovery from log-washer tailing				
Weight recovery	23.22	1.59	24.81	33.73
Iron unit recovery	42.54	2.89	45.43	60.76
Recovery from crude ore				
Weight recovery	10.39	0.71	11.10	15.03
Iron unit recovery	11.79	0.80	12.59	16.94
Analysis of concentrate				
Dry iron	58.37	59.05	58.41	58.76
Natural iron	48.38	48.05	48.36	48.40
Silica	12.75	11.75	12.69	12.38
Moisture	17.11	18.63	17.21	17.64
Total plant results				
Weight recovery	.....	.....	66.36	70.46
Iron unit recovery	.....	.....	84.88	89.06

Abstract of paper by S. A. Mahon and T. B. Counselman, presented at a recent meeting of the Lake Superior Mining Institute.

silica. The screening devices commonly used for rock rejection limit the size of coarse ore entering the plants to 4½ or 5 in. in one dimension. Secondary crushing of this material to a maximum size of about 1¼ in. conforms to the growing preference among furnace operators for finer sizing of furnace charges. In the Mesabi wash ores, particularly those from the lower wash beds, the coarse sizes are often composed of banded ore and sand, or of a mixture of ore and partly decomposed taconite. Fine crushing will liberate the sand and will powder the taconite to an extent permitting the removal of much of it in the washing process.

The first installation of equipment for this purpose was made in 1915 at the Hawkins plant at Nashwauk. A No. 7½ Gates gyratory crusher reduced the oversize of the main trommel to 2 in. The crushed ore was returned by an inclined conveyor to the crude-ore belt. A satisfactory elimination of silica resulted, but the practice was later discontinued for the reason that less of the material amenable to this treatment was encountered in the mine. The Trout Lake plant at Coleraine was the next at which this treatment was employed. Here one unit is equipped for crushing the coarse sizes. The ore is crushed first in a No. 8 gyratory set at 5 in.; then in a 10-in. Superior McCully crusher, from which the ore, reduced to 1½ in., is returned to the logs by a bucket elevator.

At the Harrison and Patrick plants, during the season of 1927, the trommel

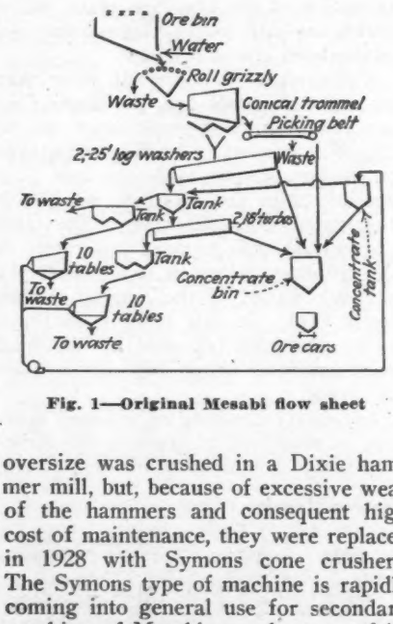


Fig. 1—Original Mesabi flow sheet

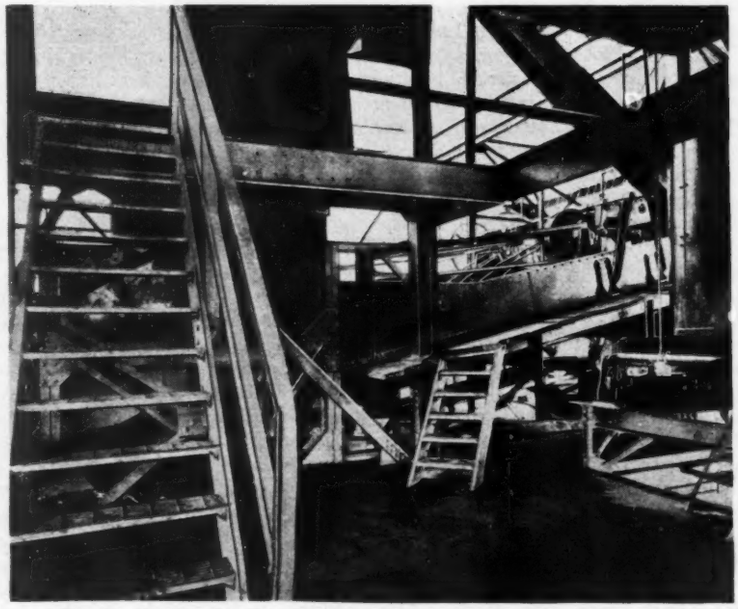
oversize was crushed in a Dixie hammer mill, but, because of excessive wear of the hammers and consequent high cost of maintenance, they were replaced in 1928 with Symons cone crushers. The Symons type of machine is rapidly coming into general use for secondary crushing of Mesabi ores, because of its wide range and great capacity. The first installation was in 1927 at the Shada plant at Nashwauk, and soon thereafter these machines were in use at the La Rue, Harrison, Patrick, and Danube plants. Two were installed in the Hill-Trumbull plant during the past winter and two are part of the equipment at the new Holman Brown plant. Difficulties, incidental to the incorporation of crushing equipment into the flow sheet at the older plants, have delayed the adoption of the type of crusher mentioned, even where the advantages of so doing are evident.

Table II—Tests on High- and Low-Grade Ores

Crude Ore		Crushed to	Washed Analyses		Plant Recovery,
Per Cent Iron	Per Cent Silica	Size, In.	Per Cent Iron	Per Cent Silica	Per Cent
46.13	28.83	1¼	59.91	9.17	69.89
		¼	59.93	8.71	65.69
		¼	60.50	8.26	65.27
39.01	40.51	1¼	51.59	23.16	60.52
		¼	53.70	19.99	58.82
		¼	54.70	19.20	56.45

At the LaRue plant the average result for the season of 1928 shows an increase of 2.74 per cent in iron content and a decrease of 4.20 per cent in silica on the material thus treated. This beneficiation, in terms of total plant production, is an increase of 1.10 per cent in iron, and a decrease of 1.70 per cent in silica content. Results of tests made at another plant on high- and low-grade wash ores are shown in Table II, the washed analyses and recovery being translated into terms of total plant output.

Flow sheet No. 2 shows in typical form the introduction of secondary crushers and the simplification of plant arrangement by the use of bowl classifiers instead of turbos and tables.



Dorr washing at Mesabi Chief plant

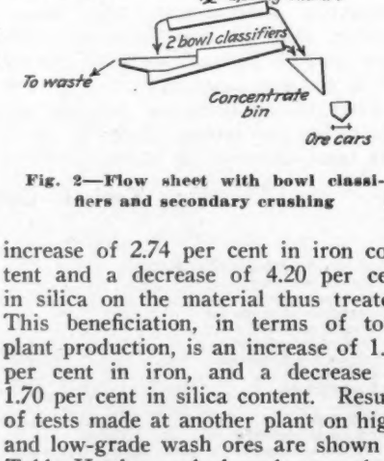


Fig. 2—Flow sheet with bowl classifiers and secondary crushing

The difficulties encountered by some operators in obtaining a satisfactory product from the 25-ft. log washers when treating low-grade ores has led to the use of different applications of screening in connection with the work of the logs. The log washer, a machine of large capacity, when given a heavy feed operates with too little washing effect and with insufficient abrasion to free the silica adhering to the coarse particles. Also, the thickened condition of the pulp forces some free silica to travel over with the concentrate, a condition that has led to the employment at some plants of

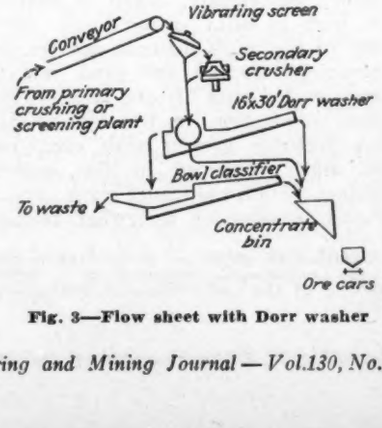


Fig. 3—Flow sheet with Dorr washer

vibrating screens as rinsing and dewatering devices for the log concentrate. These screens are placed at the discharge end of the logs, a rinsing spray washing the concentrate as it passes over the screens. The screen surfaces have free openings of from $\frac{1}{32}$ to $\frac{1}{16}$ in., and the fines passing through them are rewashed in the bowl classifier. No data on elimination of silica by this method are available, but at the Trout Lake plant the moisture content of the ore is lowered 1 per cent by thus removing the slimes.

On some ores the "frozen silica" cannot be sufficiently freed by the abrasive action in the log washers. This has led to the use of finer trommels, to wash the coarser sizes in the undersize of the main trommel. This practice is in vogue at the Harrison and Patrick plants. At these plants the initial trommel, the jackets of which have $1\frac{1}{4}$-in. round holes, is followed by a secondary trommel having $\frac{3}{8}$-in. round holes. Both the initial and secondary trommels are fitted with 5-in. channels closely placed, which lift and drop the ore under sprays of water, subjecting it to an intense abrasive action. Only the undersize of the secondary trommel is fed to the logs. A much more efficient freeing and elimination of silica is achieved by this method than was formerly accomplished in the treatment of the entire material in the logs.

Another application of screening is the replacement of the initial trommels by vibrating screens. This method of screening the crude plant feed is particularly applicable to use in connection with secondary crushing where reduction in size of the coarse material at all times is contemplated. It has been successfully done at the Danube plant.

The outgrowth of the use of finer trommel screens to make concentrate ahead of the log washers was the development of a single machine to combine the functions of the fine trommel and of the log washer. This machine, known as the Dorr washer, was developed to fit the problem of concentrating Mesabi wash ores. Its purpose was to break down the coarse- and intermediate-sized ore particles, and to rub off "frozen silica," and thus to save as much fine ore as possible. One machine does the work of the fine trommel screen, of the log washers, and partly of the bowl classifiers.

The first machine was operated in 1920, at the Mariska mine, and had a capacity of 100 tons of concentrate per hour. Two or three other machines of gradually improved design, of similar or somewhat larger capacity, were installed at other plants.

This development work led finally to a machine capable of 400 tons per hour, used during the season of 1929 at the Mesabi Chief plant. Here the main trommel is equipped with screen jackets having $1\frac{1}{4}$-in. holes. Undersize of this screen goes to the 16-ft. Dorr washer. Oversize falls on a picking belt, from which it goes to a 4-ft. Symons cone crusher, or can be bypassed to the washed-ore bins. The product from the crusher unites with the trommel undersize as feed to the Dorr washer.

Table III—Log Washer and Bowl Classifier Flow Sheet

	Dry Weight Recovery	Analyses: Dry Iron	Analyses: Natural Iron	Silica	Moisture	Iron Unit Recovery
Crude	100.00	42.87	38.93	37.05	9.02	.....
Log washer concentrate	53.67	54.48	49.74	18.32	8.70	.....
Bowl classifier concentrate	8.98	44.96	34.84	32.66	22.50	.....
Total concentrate	62.65	53.12	47.29	20.37	10.97	77.62
Tailing	37.35	16.18	.....	74.70	.....	.....
Dorr Washer						
Crude	100.00	42.68	38.92	36.03	8.80	.....
Washing barrel concentrate	31.38	51.33	48.76	22.73	5.00	.....
Rake concentrate	33.98	55.08	51.22	18.19	7.00	.....
Total concentrate	65.36	53.28	50.06	20.37	6.05	81.61
Tailing	34.64	19.08	.....	70.83	.....	.....

Original design of this plant included the use of the Dorr machine as a unit washer to account for all of the plant concentrate and tailing, with space provided for the subsequent installation of a bowl classifier if a saving could be made from the tailing to warrant such addition. During the season of 1929 the plant was operated with the washer alone. The record of the plant for the season shows a recovery in weight of 65.5 per cent and an iron recovery of 87.7 per cent.

Tests on the plant tailing indicated that an additional weight recovery of about 2 per cent could be made by following the washer with a special bowl classifier, having a 20-ft. bowl and 4-ft. rakes. This is yielding good results.

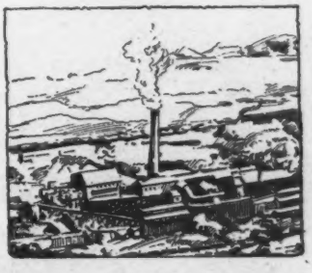
During the season of 1929 a carefully conducted test was made to determine the relative merits of the log washer and bowl classifier flow sheet, as against the Dorr washer. The information derived from this test would doubtless be of interest to those concerned with the problems arising in the washing of iron ores.

The test was made on a No. 4 wash ore containing decomposed taconite and ore, with considerable "frozen silica." The crude ore was crushed to only 1 in., with the object of determining the relative amounts of abrasion obtained in the two flow sheets. A careful split of the crushed ore was made, and half of the tonnage was treated in each of two operating plants on the range, at full capacity.

Table III summarizes the results of these test runs. Based upon dry weights, the Dorr washer made 2.71 per cent better weight recovery than the log washer and bowl classifier combination. The dry iron and silica of the concentrate from the two flow sheets was about the same, but, because of the more thorough scrubbing and removal of painty material in the Dorr washer, the moistures of its products were lower, and consequently the natural iron assay of the concentrate was 2.77 per cent higher than of the concentrate from the log washer and bowl classifier flow sheet. The iron unit recovery was 3.99 per cent higher. Because of the greater moisture in the classifier products that resulted from the use of the log washer in combination with the bowl classifier, the moist weight recoveries, as shown by railroad weights, were about the same in either case, 63.45 per cent of the Dorr washer and 63.90 per cent for the log washer and bowl classifier combination.

In the matter of relative abrasion obtained by the use of the Dorr washer, as against the log washer and bowl classifier flow sheet, screen analyses showed that there was between 40 and 50 per cent more abrasion in the Dorr washer. This increased abrasion is caused by the fact that the trommel is partly submerged and that lifters and ring dams are provided inside the washing barrel, which force the material to tumble and wear upon itself, producing an action mildly like that of a ball mill. The "frozen silica" is rubbed off by this action, and, as a result of this, screen tests showed that the coarser sizes of the concentrate from the Dorr washer ran somewhat higher in iron than the corresponding sizes of concentrate from the log washer. No additional minus-100-mesh size was produced by the Dorr washer.

As a result of the information concerning this machine thus far gained, the most recent plant being built upon the range, the double unit Canisteo plant, will follow the third typical flow sheet included in this paper. It will have as concentrating equipment two 16-ft. Dorr washers and two 20-ft. special bowl classifiers.



Another Porphyry Copper in the Making

Development of the Bagdad Copper property, near Hillside, Ariz., its prospects and reserves, with details of pilot-plant construction and operation

George J. Young
Associate Editor

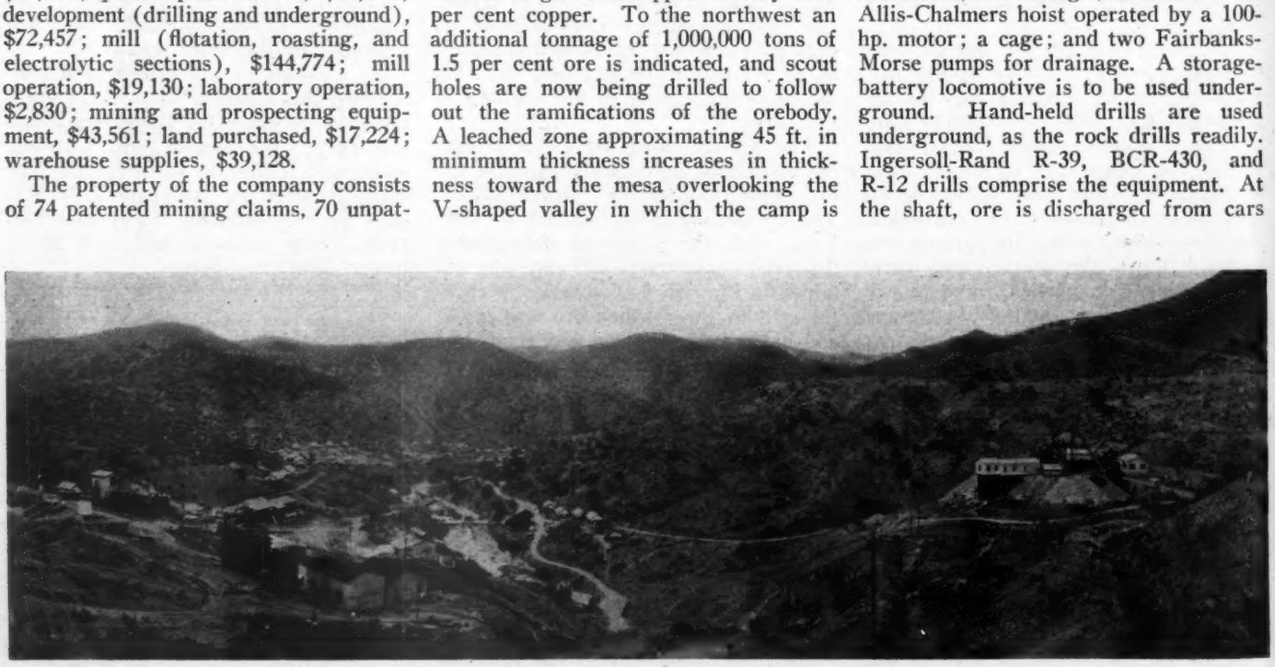
THE Bagdad Copper Company was incorporated in 1911. An unsuccessful attempt was made in that year to finance the company, and in 1912 a two-year bond was given to the General Development Company, of New York, which was relinquished the next year after churn drilling part of the property. By 1915 underground workings totaled about 8,000 ft. and drilling, 33,225 ft. In September, 1929, E. B. B. Bronson, president of the company, stated in a report to stockholders that total working capital was $1,324,277; receipts from sale of ore, interest, and other sources were $13,779, a total of $1,338,056; and total disbursements were $511,168, leaving a cash balance on hand of $826,888. Significant features of some disbursements are as follows: Camp buildings, boarding-house equipment, garage, and laboratory and warehouse equipment, $28,381; power plant No. 2, $46,391; development (drilling and underground), $72,457; mill (flotation, roasting, and electrolytic sections), $144,774; mill operation, $19,130; laboratory operation, $2,830; mining and prospecting equipment, $43,561; land purchased, $17,224; warehouse supplies, $39,128.

The property of the company consists of 74 patented mining claims, 70 unpatented claims, a town site, and a dam site; in all, 4,500 acres in the Eureka mining district about 28 miles by road from Hillside, Ariz., on the Santa Fé, Prescott & Phoenix Railway. Altitude of the camp is 3,800 ft. The Santa Maria River, 11 to 12 miles distant, intersects the road at an altitude of 2,200 ft.

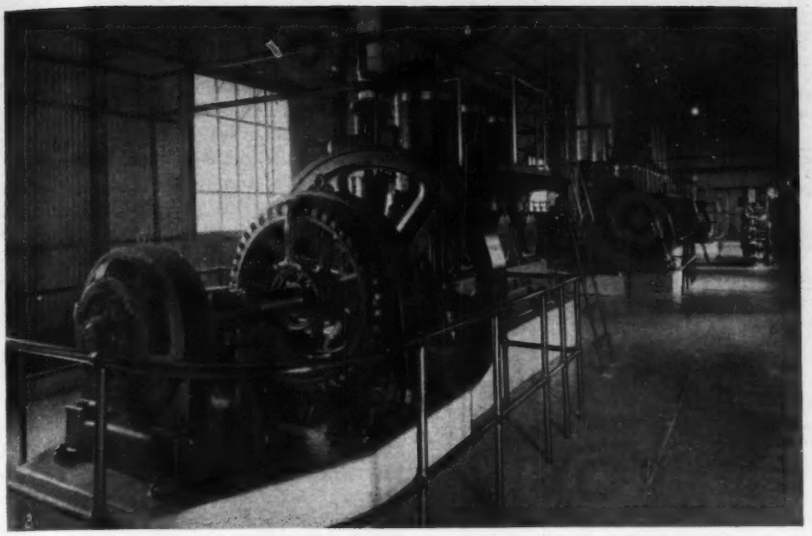
I have given the foregoing information, derived from company reports and the "Mines Handbook," chiefly because the property is of interest inasmuch as it is another "porphyry copper" in the making. I visited Bagdad in May. At that time G. G. Thomas, manager, stated that the commercial ore indicated by boreholes on a co-ordinate system of 100- and 200-ft. squares was 46,000,000 tons of a grade of approximately 1.15 per cent copper. To the northwest an additional tonnage of 1,000,000 tons of 1.5 per cent ore is indicated, and scout holes are now being drilled to follow out the ramifications of the orebody. A leached zone approximating 45 ft. in minimum thickness increases in thickness toward the mesa overlooking the V-shaped valley in which the camp is located; a chalcocite or secondary zone is also present, and, beneath, a chalcopyrite or primary zone.

Minable thickness of fair-grade ore is estimated by Thomas to be 350 ft.; length of the orebody, 1,600 ft.; and width, 1,000 ft. Diamond drilling is being done from underground stations on the lowest, or 350-ft., level of the 370-ft. shaft. This lowest level is at 2,900-ft. elevation. Development workings, including the shaft, total about 10,000 ft. In April, development approximated 860 ft., and the rate should produce about 130 tons per day for the concentrating mill. A test stope comprising a block of ore amounting to 130,000 tons is now being prepared for mining by the Miami undercut caving method with the expectation of deriving information as to the mining qualities of the ground from this work.

No. 2 shaft is equipped with a steel headframe, 45 ft. high; a double-drum Allis-Chalmers hoist operated by a 100-hp. motor; a cage; and two Fairbanks-Morse pumps for drainage. A storage-battery locomotive is to be used underground. Hand-held drills are used underground, as the rock drills readily. Ingersoll-Rand R-39, BCR-430, and R-12 drills comprise the equipment. At the shaft, ore is discharged from cars



General view of Bagdad, with No. 2 shaft, principal development opening, at right



The power plant: Diesel engines and electric generators

over a grizzly, the oversize is broken by hand hammers, and the total product is received in a wooden bin from which it is discharged upon a grizzly. Oversize is passed through a jaw crusher (set to 2 in.), undersize and crusher product being taken by an inclined-belt conveyor through a weightometer and discharged through an automatic sampler upon a Hum-mer screen, oversize going to a second crusher and both products into a bin. A two-bucket wire-rope tram delivers the ore (½ in. maximum size) to the mill bin. Churn-drill equipment consists of three Star 23 portables. No. 1 shaft, 100 ft. in depth, is equipped with a 50-ft. timber headframe, a single-drum hoist, and 40-hp. motor.

The drill-sharpening shop is equipped with Ingersoll-Rand No. 50 and No. 33 sharpeners and an oil-fired forge. A Sullivan angle-compound compressor, 1,500 cu.ft., driven by a 250-hp. motor, and a belt-driven, Imperial Type 10 compressor of 350-400 cu.ft., supply compressed air. The power plant contains two 360-hp. Diesels direct-connected to 240-kw. a.c. generators; one 180-hp. Diesel direct-connected to a 114-kw. a.c. generator; and one 75-hp. Diesel direct-connected to a 48-kw. a.c. generator. All are Fairbanks-Morse engines. Current is distributed at 440 volts. A voltage regulator and regulated frequency insure stable conditions. Each engine is connected to a liquid heat exchanger of the Southwestern Engineering Company's type and a separate Fluor cooling tower. Local water is hard, and the heat exchanger is a distinct advantage as well as affording economy in the use of cooling water. Motor-driven pumps are used for circulating the cooling-tower water. Power cost is estimated at 1¾ to 2c. per kilowatt-hour. (April power cost was 1.6c. per kilowatt-hour and May, 1.4c.) Diesel oil costs 4c. per gallon at Hillside and 6c. at Bagdad. A 9,000-gal. oil storage at Bagdad and 15,000-gal. at Hillside suffice for the requirements of the plant. Power-house switchboards are equipped so that power used for any purpose can be readily metered. Power houses are of steel frame, galvanized corrugated steel construction with cement foundations and floors.

Experimental Mill and Electrolytic Plant

A 50-ton flotation mill was used for experimental ore treatment. Concentrates obtained were treated by leaching, and the copper was deposited electrolytically. The original purpose in ore treatment was to devise a method whereby a finished product could be made. By flotation, a recovery of 87.7 per cent of the total copper, or 91 per cent of the sulphide copper, was made, the average grade of the concentrate being 37.7 per cent copper and the ratio of concentration 32.8 to 1. There is little oxide copper present; the natural *pH* of the mill circuit is 8 to 8.2. Aerofloat No. 25, 0.09 lb., and 0.06 lb. pine oil, with no lime, are used for flotation. Grinding is 10 per cent on 65 mesh and 47 per cent past 200 mesh. It is the intention to grind to 5 per cent on 65 and 50 per cent past 200 mesh.

The Wetherbee process was used in the experimental leaching plant. Fig. 1 shows the flow sheet, and also includes the flow sheet of the experimental mill.

The basis of the Wetherbee process is an oxidizing roast in three stages, the first at approximately 500 to 700 deg. F., in which part of the sulphur is driven off; the second or sulphating stage 1¼ hours at 980 deg. F., and the third stage 2¼ hours at 1,100 deg. F., during which any ferrous sulphate formed during the first two stages is broken down. A small hand-rabbled furnace was first used for roasting, but this was discarded and a small revolving roaster of the Bruckner type used thereafter. The roast results in converting the iron to a form insoluble in the acid used, and in the formation of acid-soluble copper of which some 20 per cent is in water-soluble form.

The calcine was agitated in a Devereux tank with return electrolyte from the "major cells" (20 grams copper, 80 grams sulphuric acid, and 4 to 5 grams of iron per liter). After two hours' agitation the copper is dissolved. Copper solutions were built up to 60 grams copper and with iron down to 4 to 7 grams per liter. The solution was decanted in part by a Dorr thickener and the thickened product sent to an acid-proof Oliver filter for displacement and washing. Solutions were stored in tanks and passed through two series of electrolytic cells (lead anodes, copper cathodes), the first or "major" series reducing the copper to 20 grams per liter. Part of this solution goes to the second or stripping cells, where the copper content is reduced to 5 grams per liter. The electrolyte from the stripping cells was passed through a trough filled with detinned scrap and the remaining copper precipitated as cement

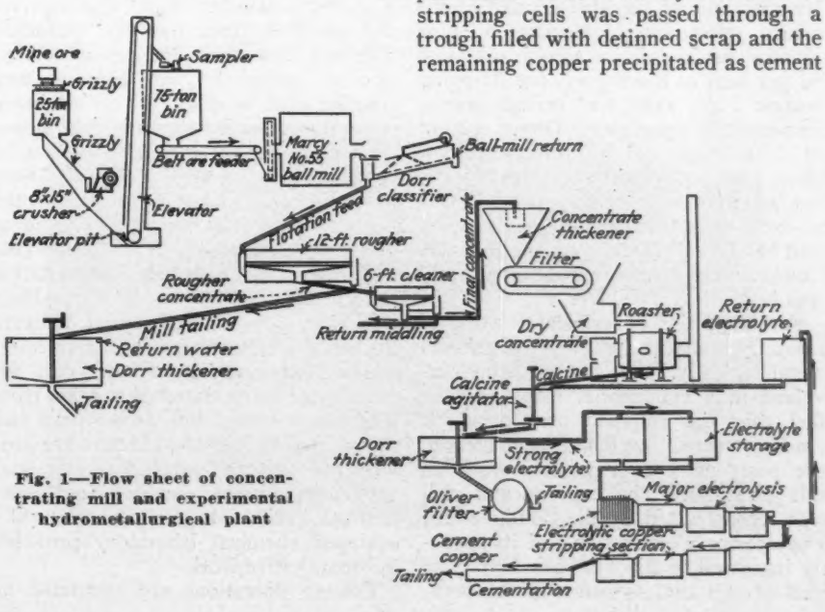


Fig. 1—Flow sheet of concentrating mill and experimental hydrometallurgical plant

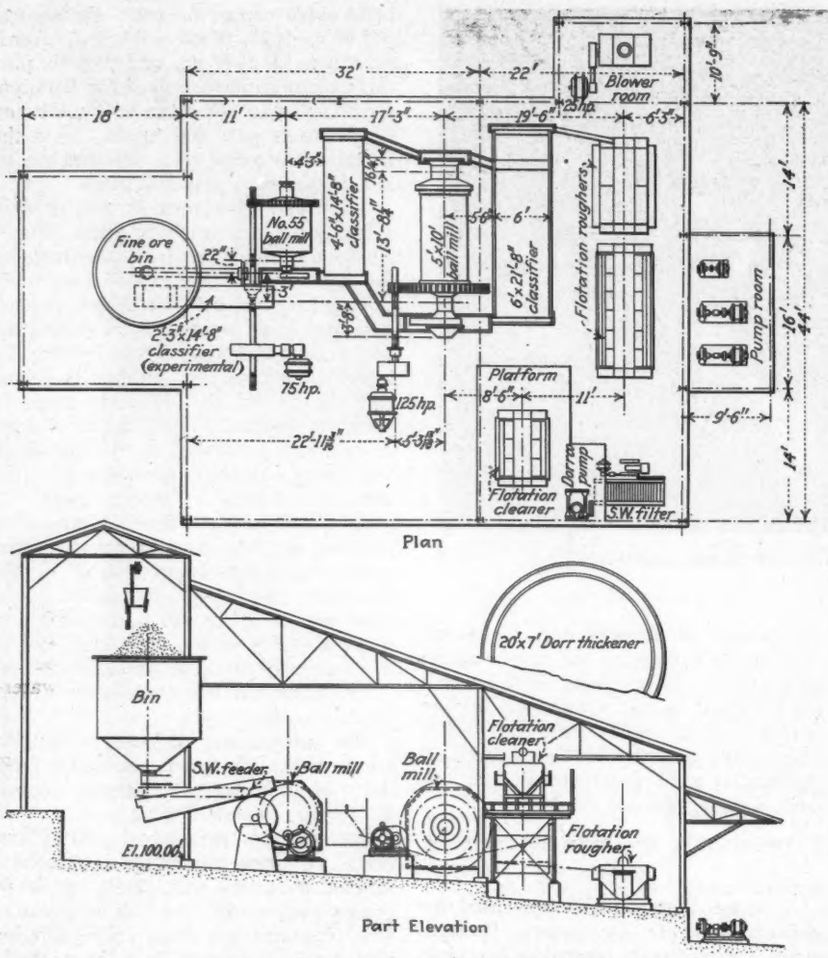


Fig. 2—Plan and elevation of 200-ton flotation mill

copper. Water-soluble copper formed during the roasting supplies more than enough new acid, and hence the reason for stripping as excess acid formed in the process is eliminated. In this process a considerable amount of the acid is regenerated, so that no acid is used for maintaining the acid content of the return electrolyte. During a nine months' run the major section produced 92 per cent of the copper, the stripping section 5 per cent, and cement copper amounted to 3 per cent. Direct current of 2,000 amp. and 50 volts was supplied. Current density was 18 amperes per square foot. A very pure copper of excellent properties was made. The unit handled all of the concentrate made. Construction of the experimental mill was begun in June, 1928.

Although the experimental work of treating concentrate was successful metallurgically, the large outlay involved in a commercial plant and the fact that the sulphide ores could be readily treated by flotation influenced the postponement of further work in this direction. The experimental mill was reconstructed by the Southwestern Engineering Corporation and its capacity increased to 200 tons per day. The plan of this mill, which was in operation when I visited Bagdad, is shown in Fig. 2. A belt feeder delivers the ore ($\frac{1}{2}$ in. maximum size) to a No. 55 Marcy ball mill in partial closed circuit with a 4½x14-ft. 8-in. Dorr classifier. Part of the sand is sent to a 5x10-ft. ball mill in closed circuit with a 6x21-ft. 8-in. Dorr classifier, which also receives the overflow from the first classifier. The overflow from the second classifier is passed to two Southwestern rougher cells in series, the tailing being pumped to a tailing pond and the rougher concentrate from the first cell to a cleaner cell at a higher elevation than the roughers. Concentrate from the second rougher is returned by a pump to the first rougher cell. Cleaner tailing returns to roughers and flotation concentrate goes to a 20x7-ft. Dorr thickener. A Dorrco pump delivers thickened concentrate to a Butler filter, which discharges into an ore car, the concentrate being trammed to a bin from which it is loaded into auto trucks and transported to Hillside. Meters are provided for return and new water and automatic samplers for mill feed, concentrate, and final tailing. A well-equipped chemical laboratory provides for quantitative work.

Present operations are restricted to development of the area delineated by the borehole exploration. The ore removed in development is sent to the concentrator, and ore grades and recoveries are determined with a high degree of accuracy. It is of interest to note that the development ore contains more copper than was indicated by the churn drilling in the horizon covered by the development workings. A large concentrator is being planned and likewise a main working shaft and water supply. Engineering work incident upon this program is now in progress and the problem of transportation to the railroad is being considered. The size of plant is as yet undetermined but may be 6,000 tons. A tentative plan to install a 1,000-ton plant, complete with electrolytic and smelter accessories to take care of development ore, is under consideration.

Bagdad includes interesting new features when compared with some of the other porphyry enterprises. Its comparatively isolated position has no doubt been responsible for the formulation of the plan to produce a metal product rather than to ship an intermediate. An unsuspected byproduct of the electrolytic research was the high-grade nature of the copper produced, and it is not at all unlikely that this copper will command a premium compared with the grade of electrolytic copper now upon the market. It also renews attention to the hydrometallurgical treatment of high-grade copper concentrate. So far, the experimental plant indicates that after roasting and extraction of soluble copper a weight reduction of from 45 to 50 per cent is obtained, with tailing as low as 1.5 per cent copper and an average of near 5 per cent. The control of roasting is the critical thing in determining tailing content. This has been recognized, and a tentative plan for treating 80 per cent of the concentrate by roasting, dissolving, and electrolytic deposition, and 20 per cent by smelting, is under consideration. Off-roasts and tailings from the hydrometallurgical treatment are to be bedded with the raw concentrate and smelted. The weight of the products to be smelted approximates 60 per cent of the weight of the concentrate. Such blister copper as is produced will be shipped or cast into anodes and used for making starting sheets. The economics of this procedure would make an interesting study and the final outcome of the novel metallurgy will be awaited with interest.

China Clay

Geology, mining, and dressing practice in the St. Austell district of Cornwall, a region that has supplied the world with high-grade china clay for many generations

Frank R. Van Horn

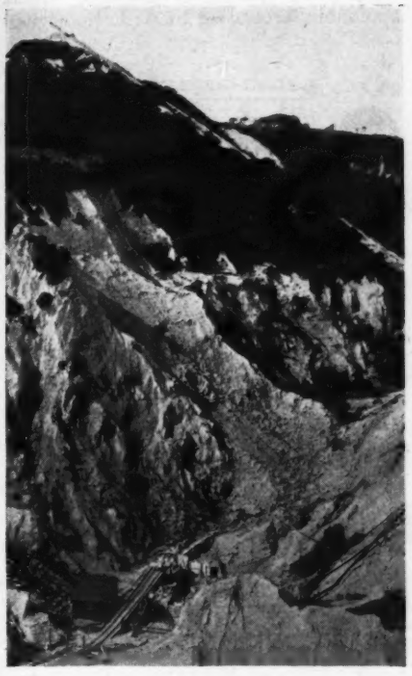


Fig. 1—A clay pit and waste dump at St. Austell

INASMUCH as the Cornwall district of England produces annually about 1,000,000 tons of china clay, of which the United States in 1928 imported about 300,000 tons, valued at nearly three million dollars, these deposits and the methods employed in obtaining the clay are of particular interest. About a year ago I had the privilege of visiting the workings at St. Austell, which is one of the most important centers of the district's china-clay operations. A record of some of the observations I made on that occasion follows.

The Cornish clay deposits, as is well known, are partial products of the decomposition of granite. A gray porphyritic granite comprises the St. Austell mass, which contains phenocrysts of perthite feldspar up to 5 in. in length in a coarse groundmass of orthoclase, oligoclase, quartz, biotite, and muscovite, with such accessory minerals as zircon, magnetite, apatite, tourmaline, topaz, and fluorite. The last four minerals contain the mineralizers chlorine, boron, and fluorine, to which Sir John S. Flett[1] and other geologists of the British Survey ascribe the kaolinization of the granite by pneumatolytic action and post-consolidation activities. G. Hick-ling[2] believes that the granite has been converted into sericite by hydrothermal action and afterward changed into kaolinite by weathering. This view does not seem to have the support of the geologists of the British Survey. For instance, J. Allen Howe[3] states: "Whether some of this kaolinite has been formed via sericite or not, it is certainly an error to ascribe its origin to weathering."

The several operations comprising the mining and treatment practice employed at the Cornish china clay properties are illustrated in the accompanying halftone cuts. A clay pit about 200 ft. deep is shown in Fig. 1. In the bottom of the pit are several rectangular troughs, known as sand pits. These are 10 to 15 ft. long, 5 to 10 ft. wide, and 10 to 18 ft. deep. The decomposed rock is washed down the inclined sides of the pit proper by small streams of water that flow from a ditch or gutter, called a "leat," which circles the pit at the surface. These streams are led to the rectangular troughs, in which the coarse particles of quartz and feldspar accumulate. When one of the sand pits is full, the streams are directed into a second pit; and the sand in the first pit is then shoveled into cars, which are hauled up an incline and dumped at the "burrow" or waste dump. These dumps, in the form of white cones, frequently several hundred feet high, are characteristic of the topography of the region.

In the bottom of the clay pit, near the sand pits, are the drags, which consist of a series of wooden channels equipped with riffles to catch the particles next in size to those that were dropped in the sand pits. The material caught in the channels is shoveled out and also taken to the waste dump. From the drags, the milky clay water passes to pumps that raise it to the surface through pipes. These pipes are seen in the lower right-hand corner of Fig. 1.

The clay water, as it reaches the surface, contains much sand and mica in suspension. This material is removed in surface drags and in the "micas," which consist of a series of parallel wooden or stone channels that total 200 to 300 ft. in length, each channel being 20 to 30 ft. long, 1½ to 2 ft. wide, and 9 in. deep. From the "micas" the flow is to square or circular pits, 20 to 40 ft. in diameter and 6 to 10 ft. deep,

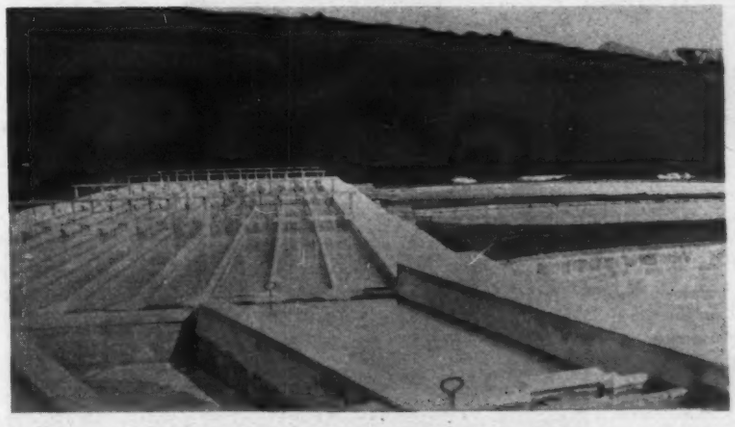


Fig. 2—Impurities are removed in the tanks at the left. Clean clay settles in those at the right

[1]Sir J. S. Flett: "The Geology of the Country Around Bodmin and St. Austell." Mem. Geol. Sur. of Great Britain, 1910, p. 65.

[2]G. Hickling: Trans. Brit. Inst. Min. Eng., Vol. 36, 1908-9, p. 10.

[3]J. Allen Howe: "A Handbook to the Collection of Kaolin, China Clay, and China Stone in the Museum of Practical Geology, Jermyn Street, London, S.W." London, 1914, p. 171.

Fig. 3—End view of settling pit, showing sloping floor

where the finer clay particles settle. Two surface drags are shown in the foreground of Fig. 2. Behind these are ten parallel rows of "micas." Three settling pits, two filled and one empty, are seen at the right. Fig. 3 presents a view of the far side of the three settling pits shown in Fig. 2.

After the clay has settled in a pit, the water is drawn off. The clay flows along the sloping bottom, seen in Fig. 3, and passes into a rectangular tank, 60 to 180 ft. long, 30 to 60 ft. wide, and 6 to 10 ft. deep. Part of a tank is shown in the left portion of Fig. 4. Adjoining the lower end of the tank are two parallel sheds, which together are known as the "dry." The first shed is called the "pan" and the second, the "linhay." From the tank the clay is either carried to the pan by truck or flows into the building as a mud, known as the "slurry." On reaching the pan the clay is placed on a trough-shaped hearth, 100 to 300 ft. long and 12 to 15 ft. wide. The bottom of the hearth is made of porous fireclay tiles that are thicker at the furnace end of the building than at the stack end, where lower temperatures prevail. Before the drying of the clay is completed, it is cut into brick-like masses, which operation accelerates evaporation and facilitates handling. Dry clay is removed daily from the furnace end of the pan, where it dries rapidly, and two or three times a week from the stack end. The lumps, on removal from the pan, are stacked in the adjoining storage shed or "linhay" (see Fig. 5) for shipment.

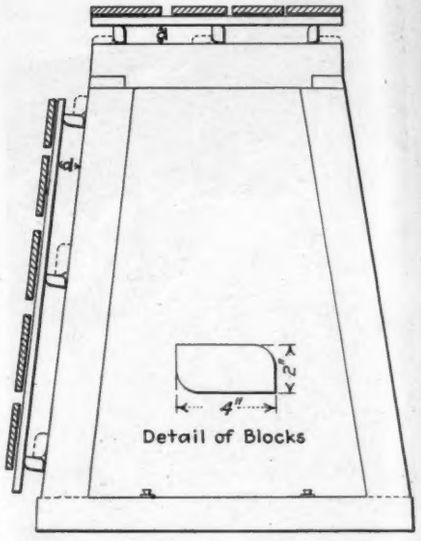
From St. Austell most of the china clay is taken by train to Par and Fowey, on the coast, where it is transferred to steamships for shipment to the United States, principally, and, in lesser amounts, to Germany, Holland, Belgium, France, Russia, Italy, and several other countries.

Fig. 4—The "dry," comprising the two sheds at the right where the clay is dried and stored for shipment

Fig. 5—Shipping side of a "linhay" or clay-storage building

Timbering in Swelling Ground

TIMBERING in swelling ground, or in ground that slakes on oxidation, such as serpentine and certain types of clay gouge, is frequently followed by expensive repairs. These are largely avoidable, according to A. I. Rodriguez,



Detail and arrangement of key blocks

of Berkeley, Calif., who explains that such ground has a definite expansion ratio, usually between 8 and 15 per cent by volume. When this expansion has occurred, the ground will take on little if any added weight by oxidation or other katamorphic effects.

Various devices have been tried to ease off the weight on the timbers in a drift through swelling ground. The following method has, in the experience of Mr. Rodriguez, been most successful:

"Key" blocks, of 2x4 in., or other suitable cross-section, are beveled on diagonally opposite corners, as indicated in the accompanying sketch. The essential point to be observed is that the distance *d* between bearing surfaces must not increase during rotation of the block. The keys, usually 8 or 9 to a set, can be made of any good scrap timber, either in the framing shed or by an experienced timberman with a framing axe. They are placed in the usual manner, between the cap or posts and the "bridging" of each set. When the swelling is sufficient to tighten all the lagging bearing against the bridge, the ground may be eased off as required by driving the key blocks around to their smallest cross-sectional dimension. With a little experience one can easily determine the correct cross-section for key blocks in any particular ground.

■ ■ ■

Upkeep of Electric Locomotives

J. S. Dean

Westinghouse Electric & Manufacturing Company, Homewood, Pa.

TO INSURE the proper speed of a motor, the field coils must have the correct number of turns. The coils should be made from a good quality of copper of the proper size of wire or strap to carry the current without overheating. They should have added insulation at sharp corners and at the pole tips, and be so shaped that they can readily be assembled in place. When wound, the coils should be treated in a gum, using the vacuum high-pressure impregnating process. After this they are carefully insulated and then dipped in a high-grade insulating varnish and baked. All coils should be given three such dipping and baking treatments. The finished coils are fitted with cable leads in preference to heavy brass terminals, the objection to these terminals being that they are likely to break off or to develop loose connections and burn off the leads. Another objection is the difficulty of properly insulating them after the external connections are made.

Before assembling the field coils, clean off all sharp burrs and edges on all poles and pole seats and paint the inside of the frame at the pole seats with a black insulating varnish. Use steel springs and washers between the field coils and the motor frame. Wipe off the surface of the pole seats and pole tips at the joints before assembling. While assembling be careful that the washers or springs do not work in at the fit between the pole and pole seat. Taping the coil spring and washers together at several points with a few turns of tape will help to avoid this trouble. Place the coils over the poles correctly, and tighten pole tip bolts until they are pulled down solid to the pole seats. When the bolts are pulled up tight, test by hitting pole lightly with a small hammer.

To insure a good electrical job, the soldering of all connections between the field coils and the wiring around the frame leads should be made under the direction of some one man experienced in this work. All leads should be cleaned and tinned before soldering. Brass or copper sleeves should be used on the brush-holder leads and on field-coil leads where the terminals are being used on the field coils. The correct winding information, with a diagram of connections, should be obtained from the manufacturer of the motors. As an additional factor of safety, it is advisable to check the polarity of both the main and commutating field coils after they are assembled in the motor frame.

To improve the operation of the brush holders, keep the porcelains clean, the shunts in good repair, and the pressure-finger mechanism working freely. When more than one finger is used per holder, adjust the tension of each finger to approximately 6 to 8 lb. On brush holders using a single finger per holder, pressures of about 10 to 12 lb. should be used. Brush holders with a single carbon per holder are more likely to give trouble, owing to a lower spring tension, than those with two or more carbons. If the single carbon jumps from the surface of the commutator, the current is broken and the motor tends to flash over to ground. Brush holders should be properly aligned on the neutral position, which is usually at the center line of the poles. They should be adjusted to about $\frac{1}{8}$ in. from the surface of the commutator and spaced around the commutator one-fourth the number of commutator bars, on all four-pole machines. Clearance between the carbon and the carbon way should not be allowed to exceed $\frac{1}{32}$ in. The ratchet-type pressure finger used on some of the older mine motors is being replaced by a more modern design, known as the twin washer fingers, which are simpler in construction and more nearly free from friction because there are no rubbing surfaces in the operation of this mechanism.

The use of high-grade carbon brushes on undercut commutators more than pays in the increased life of the brush and the commutator; furthermore, they improve the operation of the motors. When the commutators do not have the mica undercut, a hard abrasive carbon brush must be used to keep the mica cut down flush with the surface of the copper bars; otherwise, high mica will develop and cause the motors to commutate poorly.

All carbons should have a snug sliding fit in the boxes and should not be copper plated, as this plating is likely to peel off and cause sticking of the carbons. Shunts on carbons are not usually required on motors designed for 500-volt operation. On the other hand, they are generally used on the carbons for motors operating on 250 volts, owing to the heavier working currents required by these motors.

Housings or frame heads must be kept tight, so as to prevent wear, not only of the housing but on the motor frame at the housing seat. The clamping bolts holding the motor frame halves together must be drawn up securely, as the clamping action of the frame, along with the bolts or dowels, prevents the housing from turning and working loose. Sometimes these parts work loose in service, and, as a temporary means of relief, shims are used to keep them held in place, but best results are obtained by welding up the worn seats on the motor frame and remachining them to standard size, and using new housings.

Where trouble is experienced with motor frame and axle cap bolts of older motors working loose or breaking, some thought should be given to the modern practice of using special high-grade heat-treated bolts. Comparative tests show that a heat-treated axle steel bolt has an elastic limit of more than double that of the standard hardware bolt. The heat-treatment (quenched and drawn) makes these bolts both tough and strong. The amount these bolts will stretch without taking a permanent set (rubber-band action) is about double that of the standard hardware bolts. In general, this type of bolt costs from two to three times as much as the standard hardware bolt, but experience has shown that it is economical, because of the economies effected in reduced maintenance. Heat-treated bolts are furnished as standard on all modern motors.

Sleeve-type armature bearings are used on a large number of mining locomotive motors. Replacement bearings should measure up to the following essentials: (a) Shells should be made from a good grade of bronze alloy. (b) The bore should have a smooth finish. (c) The bearing bore need not be tinned nor lined with a babbitt metal. (d) Oil grooves should be cut in the bore, especially at the collar end. (e) Sides of the window should be chamfered. (f) The outside of the shells should have a smooth machine finished surface. (g) Bearings should be given at least .006-in. initial clearance with the shaft. (h) In addition to a press fit of from two to five tons in the housings or heads, the bearings should be held in place by some other means, preferably a key.

A number of the mine motors are fitted with ball bearings on the armature, and some few use roller bearings. Replacement bearings of these types should conform with the following requirements: (a) Balls or rollers, and both races, should be made from a high-grade alloy steel, hardened. (b) The inner race should have a tight shrink fit on the shaft. (c) The outer race should be a sucking fit in the bearing seat on the housing or head. (d) The bearings

The third of a series of articles on the subject of the repair and maintenance of electric transportation equipment.

must be carefully handled and kept free from dust, dirt, and moisture, during storage and when being applied.

Axle bearings are of the sleeve type and made in two halves so that they can be applied to the axle without removing the wheels. Modern practice for axle-bearing replacement conforms with the following: (a) The half shells should be made from a good grade of bronze alloy. (b) The bore should have a smooth finish. (c) The bore need be neither tinned nor lined with a babbitt metal. (d) Oil grooves are not considered essential. (e) The sides of the window and the sharp edges at the split should be chamfered. (f) The outside of the shells should be machined to a smooth even finish. (g) Initial bearing clearances on the axle should be at least 0.015 in. (h) All shells should be held by dowels or keys in addition to the clamping of the axle caps.

Because some few of the older types of motors have malleable iron shells lined with babbitt metal, bronze shells sometimes are relined with babbitt after being badly worn. However, when possible, they should be replaced by new bronze bearings.

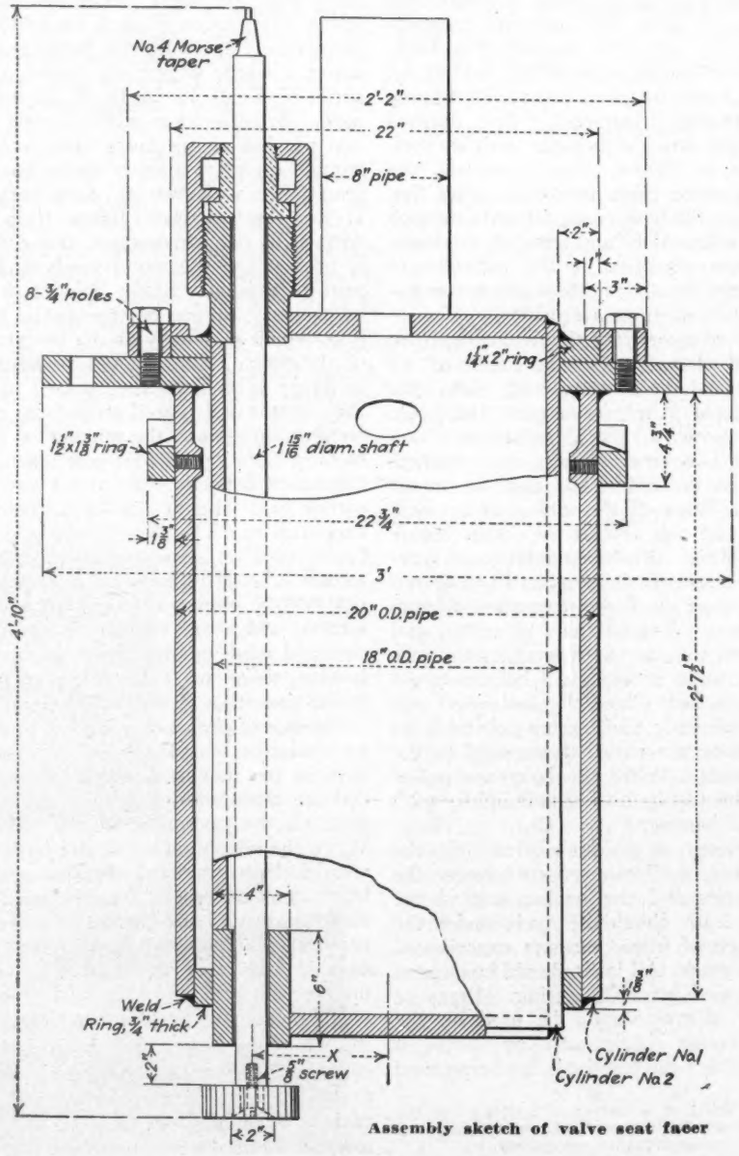
■ ■ ■

Small Milling Unit Reconditions Valve Seats

TO ASSURE continuous service and maintain high efficiency of a reciprocating pump, tight and well-secured valves are essential. Loose valves, permitting a leaking through of water between the valve proper and the valve deck seat, which is generally milled or turned into the suction or discharge chambers of the pump, will result in corroded and pitted valve deck seats, with consequent loss of pumping capacity. Chambers of small dimensions can easily be placed in a lathe and the seats rectified. When of larger dimensions, however, difficulties are encountered, because at many properties a sufficiently large lathe or boring machine is not available, and the purchase of new chambers is therefore inevitable to again put the pump in a serviceable condition.

The mechanical department of the Miami Copper Company, at Miami, Ariz., recently confronted with a similar problem on a large plunger pump, successfully reconditioned the damaged valve deck seats with a specially designed small revolving milling machine, according to F. J. Martin, assistant master mechanic. The apparatus, as shown in the accompanying sketch, consists of two welded and machined cylinders, a mild-steel guide ring, and an adjustable steel spindle. One end of the spindle is fitted with a Morse No. 4 taper, the other end carrying a small side cutter. Two smaller guide rings are provided on the stationary cylinder No. 1 to insure a perfect alignment of the inserted and revolving cylinder No. 2. To avoid any adjustment of the cutter by the operator, which requires considerable time, the milling spindle is installed and spaced so that the distance indicated by *X* in the sketch corresponds to the exact radius of the valve deck seat. A simple adjusting device and a welded-on 8-in. pipe nipple, both installed on the top of cylinder No. 2, facilitate the lowering and raising of the cutter and the revolving of the cylinder. Operation of the device is simple. The entire unit is placed into the pump chamber, and the flange of cylinder No. 1, by means of chamber studs and nuts, is tightly secured to the pump chamber. Next, a small air or electric drilling machine is attached to the tapered end of the milling spindle. After the cutter has been adjusted and the first guide cut made, a small cable suspended from a hand winch is wound in coil form around the 8-in. nipple. The cutter is then placed in operation, and the operator, by slowly rewinding the connected cable onto the small winch, automatically effects a turning of the entire revolving cylinder, thus rectifying the uneven valve seat.

To avoid interruption of pumping service, a valve at a time was reconditioned during temporary shutdowns of the pump.



Assembly sketch of valve seat facer

Microscopic Examination of Ores

P. Erimesco

Freiberg, Germany

THE use of the reflecting microscope has become more and more important. For the modern geologist it is now an indispensable aid, inasmuch as certain geological problems can be solved only by examining with incident light the ores involved in such problems. The broadened knowledge that ore microscopy has provided concerning already well-known deposits, and its value to the mining geologist, are evident in the accounts of recent geological investigations that follow.

The last time some of the ore deposits of the Erzgebirge were re-examined by the Geological Institute of the Bergakademie Freiberg, the conclusion was reached that they are all related to the same granitic magma. Segregation began with pneumatolytic processes, forming contact deposits on the peripherical zones and typical tin-ore deposits on the tops of the gas-soaked but already solidified granitic domes. Cessation of igneous activity was followed by the segregation of various ores of hydrothermal origin with typical paragenetic relations, such as those at Freiberg, Annaberg, Schneeberg, and Johanngeorgenstadt.

H. Reh proved that the numerous contact deposits belong to the same stage of formation. The succession of the different ores could be stated exactly by microscopic examination. Owing to the presence of cubanite in the blende, which occurs in abundance, the conclusion was reached that the sulphides are also of pneumatolytic origin, and not, as formerly supposed, hydrothermal products. On the basis of this microscopic examination, the temperature of deposition must have been much higher than was formerly supposed.

Examination of the hydrothermal veins also yielded new information. Oelsner showed that the stannite, present in abundant quantities, occurs almost without exception in the form of segregations in the blende. This knowledge, obtainable only by microscopic examination, gives a valuable hint for estimating the temperature of deposition. The abundant presence of segregations proves hypothermal origin.

An extensive search of the cobalt-nickel-silver formation of the Erzgebirge, by K. Keil, also yielded much new information. He states that the veins show a surprising similarity to those of Cobalt, Ont. They differ only in the temperature of deposition. Without doubt, the veins of the Erzgebirge must have been formed at a temperature between 100 and 200 deg. C., because no sign of an alloy among the numerous native metals is noticeable. Keil also proved that native silver, which occurs frequently, is of primary origin. Concerning the genesis of the minerals, Keil states that the succession of minerals in veins depends generally on the sequence of electric potential differences—a hypothesis meriting further research.

Other investigations of much interest were made by Pilz and Donath. Their studies of the tin orebodies in Bolivia proved that these rich deposits were not formed by decomposition of a primary zone carrying stannite, as was supposed by Ahlfeld and others. Microscopic examination of the ores of the Vila Apacheta mine shows clearly that both the tin ore and the pyrite were formed from a colloidal state; their origin therefore must be hypogene.

A further interesting result of the microscopic studies was the statement that stannite occurs only with minerals formed at high temperatures, and that the hot solutions carrying zinc, iron, copper, and tin dissolved again the cassiterite present, thus forming stannite as a secondary product. At El Salvadora mine the blende, containing about 1.4 per cent tin, was to be sold as tin ore, but microscopic research revealed that only a small part of the tin could be recovered. The ore showed a high content of stannite in the form of segregations, which caused the plant to fail. Cassiterite, which could be easily recovered, formed only a small part of the ore.

I have endeavored to show how important microscopic examination has become for both the mining geologist and the plant engineer. Such examinations unquestionably provide a means of determining many facts concerning ores that heretofore have been unknown.

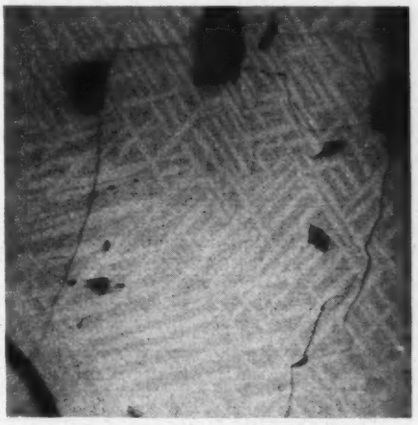


Fig. 1—Segregations of chalmersite in chalcopyrite. Magnif. 400:1. Schwarzenberg, Saxony.

Fig. 3—Dendrites of silver crystals, surrounded by rammelsbergite, safflorite, and calcite. Magnif. 18:1. Schneeberg, Saxony.

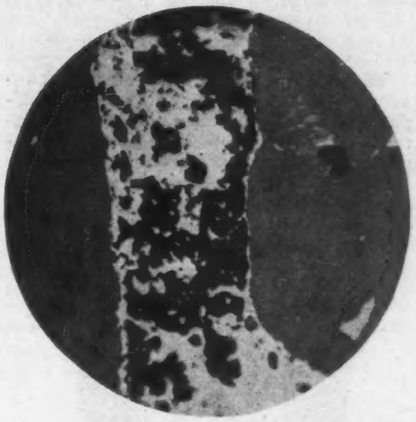


Fig. 4—Residues of cassiterite (dark gray) surrounded by stannite (grayish white) in blende (gray). Magnif. 450:1. Mina El Salvador, Bolivia.

Fig. 2—Segregations of stannite (gray) in blende (dark). Magnif. 40:1. Freiberg, Saxony.

Personal Notes . . . Comment . . . Criticism

W. B. Cramer, until recently consulting engineer to the concentrating department of the Phelps Dodge Corporation at Douglas, Ariz., has been appointed consulting metallurgist to the Marcy mill division of the Mine & Smelter Supply Company, with headquarters at Denver, Colo. Mr. Cramer,

W. B. CRAMER

who was graduated from Yale in 1902, represented the Old Dominion company at the original flotation tests conducted at Globe and Inspiration in 1913, being appointed metallurgist to the Old Dominion company in the following year. In 1917 he joined the concentrating department staff of Phelps Dodge, taking part in important investigations in connection with mill design and operation at Bisbee, Ariz.; Tyrone, N. M.; and Nacozari, Mexico. He was appointed consulting engineer to that department in 1923.

W. W. Mein, of San Francisco, has returned from Africa.

James Douglas has returned from Paris to his home at Douglas, Ariz.

Marshall D. Draper, who recently returned from Mexico, has established offices in the Hollingsworth Building, Los Angeles.

Prof. **Heinz Molivets** and Prof. **E. W. Ergn,** of Germany, recently inspected the mines of Anaconda Copper Mining, at Butte, Mont.

John B. Kasey has returned to New York from the U.S.S.R. He was formerly a member of the metallurgical staff of National Lead.

Dr. **Alfred Merton,** of the Metallgesellschaft and the Metallbank, arrived in New York on Nov. 11. He expects to return to Germany on Dec. 5.

Walter D. Abel, formerly associated with the California State Corporation Department as mining engineer, recently opened an office for private practice in Los Angeles.

Silas L. Gillan, mining engineer, was recently elected president of the Engineers' Club of Los Angeles, in which city he has maintained an office as consulting engineer for nine years.

Alberto Terrones B., having terminated his tenure of office as provisional governor of the State of Durango, Mexico, has established an office as consultant, in the city of Durango, Durango.

Sherwin F. Kelly, until recently assistant manager of Schlumberger Prospecting Methods, New York and Toronto, is now engaged in consulting work and lecturing in geophysics and geology.

L. S. Cates, president of the Phelps Dodge Corporation, is chairman of the mining industries division of the Emergency Employment Committee, which is raising money for the relief of unemployment in New York.

Alexander A. Zeidler, chief engineer of nickel plant operation for the Giprotsvetmet, returned to Russia on Oct. 31, after a five months' visit in the United States and Canada, for the purpose of studying metallurgical operations.

Guy C. Riddell left New York on Oct. 24 for Moscow, having been retained as consultant to the State Non-Ferrous Metal Trust, and assigned to work with the Soviet Department of Labor on Russian and Siberian problems.

Doane Eaton, president of the Metropolitan New York Society of the 23d Engineers, 50 Morningside Drive, New York City, requests the names and present addresses of members of that regiment who served with it during the World War.

V. V. Clark, who recently completed examination work in Colombia for Yuba Associated Engineers, has returned to Colombia for Pennsylvania interests, to investigate gold-bearing gravels. His address until February will be Puerto Berrio, Colombia, South America.

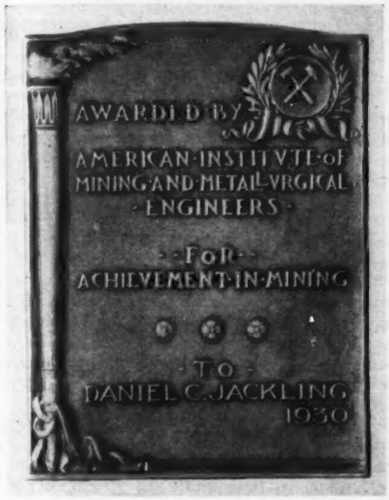
Duncan MacVichie, mining engineer, of Salt Lake City, Utah, announced recently his presentation of his technical library to the University of Utah School of Mines. The library contains all the publications of the A.I.M.E. since 1887, when Mr. MacVichie joined the Institute.

C. H. Benedict, chief metallurgist of Calumet & Hecla Consolidated, was the spokesman of the Michigan copper producers at the recent Interstate Commerce Commission hearing at Chicago. The hearing was investigating the Lake cargo coal rate. Mr. Benedict stated that the cost of coal to the copper producers amounts to one-eighth to one-tenth of the cost of production. Higher coal prices, he claimed, would be a serious blow to the industry, especially in a time of depression such as the present.

George J. Young, associate editor, *Engineering and Mining Journal,* will exhibit several of his etchings at an exhibition of art objects made by engineers to be held in the Engineering Societies Building, New York City, Dec. 1-5, in conjunction with the annual meeting of the American Society of Mechanical Engineers. The exhibition will include oil paintings, water colors, pen and ink sketches, etchings, and sculpture, as well as articles in the field of the industrial arts. More than sixty engineers have signified their intention to exhibit. At the opening on Dec. 1 a leader in the world of art will discuss the exhibition and the value of art as an avocation for the engineer.

Charles F. Williams, district mining supervisor, U. S. Geological Survey, stationed at Miami, Okla., who is a licensed airplane pilot and the owner of the monoplane shown in the accompanying illustration, writes as follows regarding a recent trip to MacAlester, Okla., and return that was made in connection with his official duties: "Heavy rains and strong head winds were encountered north of the Canadian River, but the 315-mile trip was completed without difficulty in 3½ hours' flying time at an average speed of 90 m.p.h. Three stops were made en route. The terrain flown over and the weather encountered may be considered as representative of average flying conditions in the West. The cost of the gasoline and oil used was about $12.60, or 4c. per mile. Depreciation and repairs that may be charged against the trip are comparable to similar motor car charges. It is believed that this trip, though relatively short, demonstrates the practical advantages of using small aircraft in the general supervision of mineral-leasing activities west of the Mississippi River."

D. C. Jackling was presented with the Saunders gold medal of the A.I.M.E., for conspicuous achievement in mining, at a banquet held in New York City on Oct. 28. John Hays Hammond acted as toastmaster. W. S. Boyd, of the Jackling organization, gave an account of the technical and humanitarian aspects of the work done, particularly in Utah. Other speakers included Lafayette Hanchett and Newcomb Carlton, president of the Western Union Telegraph Company. The presentation of the award was made by the president of the Institute, William H. Bassett.



John F. Hanst, at one time chief engineer for a Lake Superior iron mining company, who recently joined the engineering and sales staff of the Pittsburgh Valve, Foundry & Construction Company, at Pittsburgh, as announced in the issue of Aug. 9, is the author of a short story entitled "The Hoodoo Mine," which graces the pages of the October *Blue Book Magazine*. He recounts a hair-raising experience he had when a cub engineer in a Michigan iron mine. Even the seasoned miner will get a thrill at reading how, on one occasion, when Hanst and his helper were being lowered, riding the bail, the skip suddenly stopped, and an instant later a shower of rock descended, whizzing past them, either into the skip bottom or down the shaft, and hurting neither, save for a minor bruise apiece. The hanging had sloughed off some 500 ft. above. Broken rock covered the skip bottom to a foot in depth. Then the skip started down again and they reached the bottom 200 ft. below without further mishap. Later that day the hoisting rope snapped and the same skip fell in the shaft, 1,600 ft. to the bottom, taking the timbers with it. A hoodoo indeed!

R. D. Leisk, of the staff of United Verde Extension, draws attention to an error in the description of the company's new concentrator at Clemenceau, published in the Oct. 9 issue. An unfortunate transposition of type occurred in regard to the metallurgical results for August, 1930. The corrected figures for these results are:

	Silver	Gold
Feed, oz.	0.94	0.049
Concentrate, oz.	1.90	0.104
Tailing, oz.	0.32	0.011
Recovery, per cent	78.91	85.66

Stimulating Non-Ferrous Metal Consumption

To the Editor of "E.&M.J.":

The catalogues of mail-order houses show an unreasonable discrepancy between the cost of fabricated articles of copper, lead, and zinc and the market price of these metals, especially when comparing them with the same articles made from iron. This situation is harmful to producer and consumer alike. The fault is evidently in the fabrication. A 2-in. T fitting, for instance, weighing 3 lb., when made from iron sells in stores for 60c. Made of copper, the metal value at present prices would be about 30c., half the retail price, leaving 30c. for fabrication, distribution, and profit. Few would not gladly pay 75c. for this T made from copper or brass; but it cannot be bought for anything like that amount. A rough brass T is listed at $2.80, a buffed (finished) T at $4.20—a charge of $3.60 for 3 lb. of brass worth about 27c.

Another case is even more to the point. A 4-in. iron cock is listed at $19. With a brass washer, weighing perhaps one pound, the price is $22.50, or $3.50 extra for a pound of brass. And the brass washer is as cheap, if not cheaper, to manufacture. If this iron cock is equipped with brass plug, the price soars to $40. In other words, the consumer is charged $21 for the difference between an iron and a brass plug. Although the cost of rolling is only a few cents per pound, copper sheets sell well above 60c. per pound. Why that enormous difference—about 500 per cent? Pig lead is listed at 14c. per pound, a price uncalled for with lead at 5.5c. If producers were getting such prices, lead mining would be booming. For lead sheets, costing but little to make, the discrepancy is even more marked. Zinc sheets are listed at 15c., semi-wholesale, and pig tin is selling at 80c. and more.

The remedy is obvious. The miner sells his ore to the smelter, and the smelter to the refiner, the refiner sells to the fabricator, either directly or through a jobber. The fabricator sells to a jobber, to a wholesale house, or in rare instances directly to the consumer.

Suppose the smelter or refiner would undertake fabrication of standard articles, selling directly to the retailer or consumer. A few mining companies, such as Anaconda and Phelps Dodge have had the vision to make a start in that direction. If more companies would adopt this idea, they would not only make a modest and legitimate direct profit, but they would benefit greatly from the increasing consumption of the metals. The consumer, at the same time, would not only derive economic benefit, in paying sane prices, but would enjoy having articles made of material superior in appearance and enduring qualities.

Vanadium, N. M. ALFRED ROOS.

[Mr. Roos' arguments can be applied with even greater force as a stimulant to the use of silver. Action was urged in this respect by *Engineering and Mining Journal* in its issue of Jan. 23, 1930, in the following words: "Householders and gift givers in large numbers would purchase sterling silverware if the prices were reasonable—if the cost bore some logical relation to the market price of the metal. One suggested solution of the problem is for a few of the more progressive silver producers to follow their product through to the ultimate consumer—to apply engineering common sense to the economic problems of manufacture and distribution to Mr. Average Citizen. Research, careful planning, a necessary investment in fabricating facilities, and judicious advertising might thus bring a small but welcome profit to such a subsidiary enterprise, prevent the further demoralization of an important mining industry, and stimulate a confidence in the future of silver that is sadly lacking at present."—EDITOR.]

Dr. Edward H. Williams, Jr., was honored on Oct. 11 at Lehigh University by the dedication of a bronze tablet commemorating his founding of the Tau Beta Pi honorary engineering society at that university in 1885. Dedication of the tablet was an outstanding feature of a convention of the society that was attended by delegates from every chapter, representing 56 universities. Dr. Benjamin L. Miller, professor of geology at Lehigh University, in making the dedicatory address, paid high tribute to Doctor Williams as having attained distinction as an educator, a geologist, an engineer, and an author. He pointed out that, in organizing an honorary engineering fraternity that would serve for technical students the same purpose that Phi Beta Kappa does for arts students, Dr. Williams had made a significant contribution. "Tau Beta Pi," said Dr. Miller, "has lived in a period of the most rapid industrial development of human industry, and one only needs to call the roll of our members to realize how much a part of this advance is due to the achievement of its initiates. Tau Beta Pi helped to dignify the technical professions, which were at one time placed on a lower intellectual plane than those of the arts, and, in turn, engineering has contributed its services in the betterment of human life in many ways."

■

Tonopah Geology

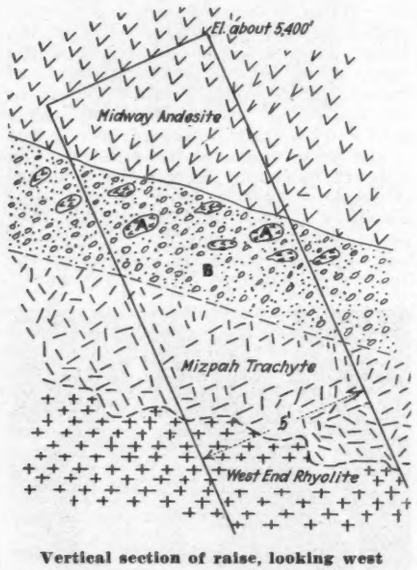
To the Editor of "E.&M.J.":

Congratulations are due Mr. Thomas B. Nolan, of the U. S. Geological Survey, on his recent bulletin on "The Underground Geology of the Western Part of the Tonopah Mining District, Nevada." The bulletin is No. 4, Vol. XXIV, of the University of Nevada, published in co-operation with the Nevada State Bureau of Mines and the U. S. Geological Survey. The block diagram, cleverly made, is the best illustration that has appeared to show

the complicated geology of the western part of the district. Deductions with regard to the relations between formations, flows and intrusives, faulting, and vein formation are better supported by the evidence that is found underground than any other conclusions that have been previously published.

One fact not brought out in the diagram is that a vein on a strand of the Tonopah fault was developed to about 800 ft. below the lowest level shown on the diagram; and important orebodies were found on some of these lower levels. The total depth reached was about 2,400 ft. vertically below the level of the town. Workings on the hills add several hundred feet to the vertical range.

The Midway andesite has not been observed by the writer of the bulletin (p. 16); and he has not seen any specific reference in the literature to a case where this rock has actually been found to cap a vein. I think that the Midway andesite actually exists; but there has been endless confusion between it and the Mizpah trachyte. For instance, blocks of rock have been mapped as Midway andesite, a post-mineral formation,



Vertical section of raise, looking west

A—Boulders, about 1 ft. diameter, of nearly fresh andesite of a purplish color, similar to that in the solid layer above. *B*—Layer, several feet thick, of soft oxidized material resembling soil or subsoil.

and have later been found to carry important bodies of ore. Several years ago I decided that the Midway andesite did not reach to the depths then being mined in the western part of the district (1,200 ft. and deeper); although earlier mapping had shown it at least as deep as 1,540 ft. The Midway andesite probably does not reach depths of more than a few hundred feet in the western part of the Tonopah district; and in the years since Tonopah was discovered (about 1900) practically all of these early, shallow workings have caved. The accompanying sketch, drawn from memory, although not showing the Midway andesite capping a vein, does show that there was a flow of andesite of much later age than the Mizpah trachyte. This sketch is of a raise from workings to the far west, and the layer of soft, oxidized material several feet thick is interpreted as the soil of an old surface. It contains pebbles apparently of Mizpah trachyte, but they are so decomposed that they crumble when squeezed in the hand. The boulders of hard, fairly fresh andesite are interpreted as fragments ejected from a vent to such a height that they buried themselves in the soil when falling. A purplish color characterizes the layer above, which is of nearly fresh, solid, unbrecciated andesite, and is similar to that outcropping near the main office of the Tonopah Extension mine. The relations described are complicated a little by faulting along the plane of weakness, represented by the layer of soft oxidized material; but they seemed fairly clear. Raises a little further west passed from the West End rhyolite into the Fraction breccia, a formation of very different appearance.

Of great economic significance is the grouping of the Tonopah rhyolite, the Montana breccia, and the Glassy trachyte as the Tonopah formation. Montana breccia is definitely ore-bearing; the Tonopah rhyolite has been considered a post-mineral intrusion, particularly in the eastern part of the district. A definite policy has existed of discontinuing prospecting in blocks that were identified as Tonopah rhyolite. If the new grouping is correct, the possibility of finding ore in these blocks is indicated. This matter will, no doubt, receive further attention in the final report, the bulletin mentioned in the foregoing being only a preliminary report.

Redding, Calif. CHARLES VOLNEY AVERILL.

Revising the Anti-Trust Laws

To the Editor of "E.&M.J.":

It is an evident fact that raw commodities are being produced almost universally beyond present consumptive demand. This condition is world-wide. What can be done in the case of commodities such as wheat, cotton, coffee, and sugar, the producers of which constitute a vast army of farmers—widely scattered and comparatively unorganized—is a tremendously difficult problem, and one which does not directly concern the metal trade.

What can be done in the case of nonferrous metals is much simpler, because here the producers are numbered by the dozen instead of the thousand. The problem is simply that of limiting production to consumption, at the same time keeping prices at such levels as to discourage the development of new mines until such time as their output will be needed, and to encourage the consumption of the product.

I am convinced the leaders of American industry can so regulate their businesses, provided they are permitted to agree with one another in the premises, with, of course, the full knowledge of the national government. Any such agreement at present under the anti-trust laws would be illegal and unenforceable. The Europeans have discovered that when such agreements have been made under the law, generally some interests will not observe limitations agreed upon, unless penalties for infractions are provided for, and collectible from deposits put in trust for that purpose. This procedure should also be permitted under our laws. Human nature is the same here as there.

Our anti-trust laws were put on the statute books during the infancy of our industries, when business men were actuated by such precepts as "charge all the traffic will bear" and "the public be damned." Is it not fair to assume that our business leaders have outgrown their swaddling clothes, and in enlightened self-interest will not disabuse powers which all other nations have found necessary for the proper conduct of their business? The alternative is vicious, cut-throat competition, continued until the weaker units have been eliminated, with concurrent exhaustion of natural resources which cannot be replaced, and lower profits and dividends for an extended period—for even the strongest units.

Should not the entire non-ferrous metal industry join in a petition to our incoming Congress, to give relief in this vitally important matter, and to give it quickly in view of present distressing conditions?

New York, N. Y. ENGINEER.

[*Engineering and Mining Journal* welcomes a reopening of this subject. Late in 1927 and throughout 1928 this publication urged the modification of the Sherman Act, in the hope that co-operation might be substituted for wasteful competition and price paring. A measure was proposed by Senator Copeland that would exempt the bituminous coal industry from the provisions of the Act, and readers of *Engineering and Mining Journal* were reminded that they might, if so disposed, urge its amendment to include those metal-producing industries that anticipated the conditions that have since arisen. Any such modification was discouraged by the Department of Justice, however, through the Assistant Attorney General. The time was not appropriate for action, public opinion being unformed. Those who believe that existing restrictions are harmful to industry were glad to note that the President on Oct. 6 last, hinted a change in sentiment in government circles. If existing legislation is hampering progress in the coal industry, he reminded his hearers, it should be modified.—EDITOR.]

OBITUARY

J. M. Cunningham, Jr., office manager for the Mancha Storage Battery Locomotive Company, died on Oct. 16.

Cassius A. Fisher, geologist and mining engineer, died at his home in Denver early in November, after a short illness. He was senior member of the firm of Fisher & Lowrie.

Henry D. Laraway, of the staff of the General Engineering Company, Salt Lake City, died on October 24, after an illness of six days. He had been with the company for fourteen years.

Perry B. Fuller, of Salt Lake City, Utah, died recently. He was born in Iowa in 1876, and was taken to Utah when a small boy. He was superintendent at one time of the properties of the Knight interests.

William W. Copp, geologist, of Los Angeles, died on Oct. 20 at the U. S. Veterans' Hospital, San Fernando, Calif., of an illness contracted while serving as a first lieutenant of engineers during the World War.

Charters S. Maltby, mine operator, of San Francisco, died on Oct. 12, at San Mateo, Calif. He obtained his first mining experience in the Klondyke district, after which he went to San Francisco, where he became a broker in nonmetallic minerals. His activities widened to the control and operation of several properties.

PLUNGER PUMP CHART

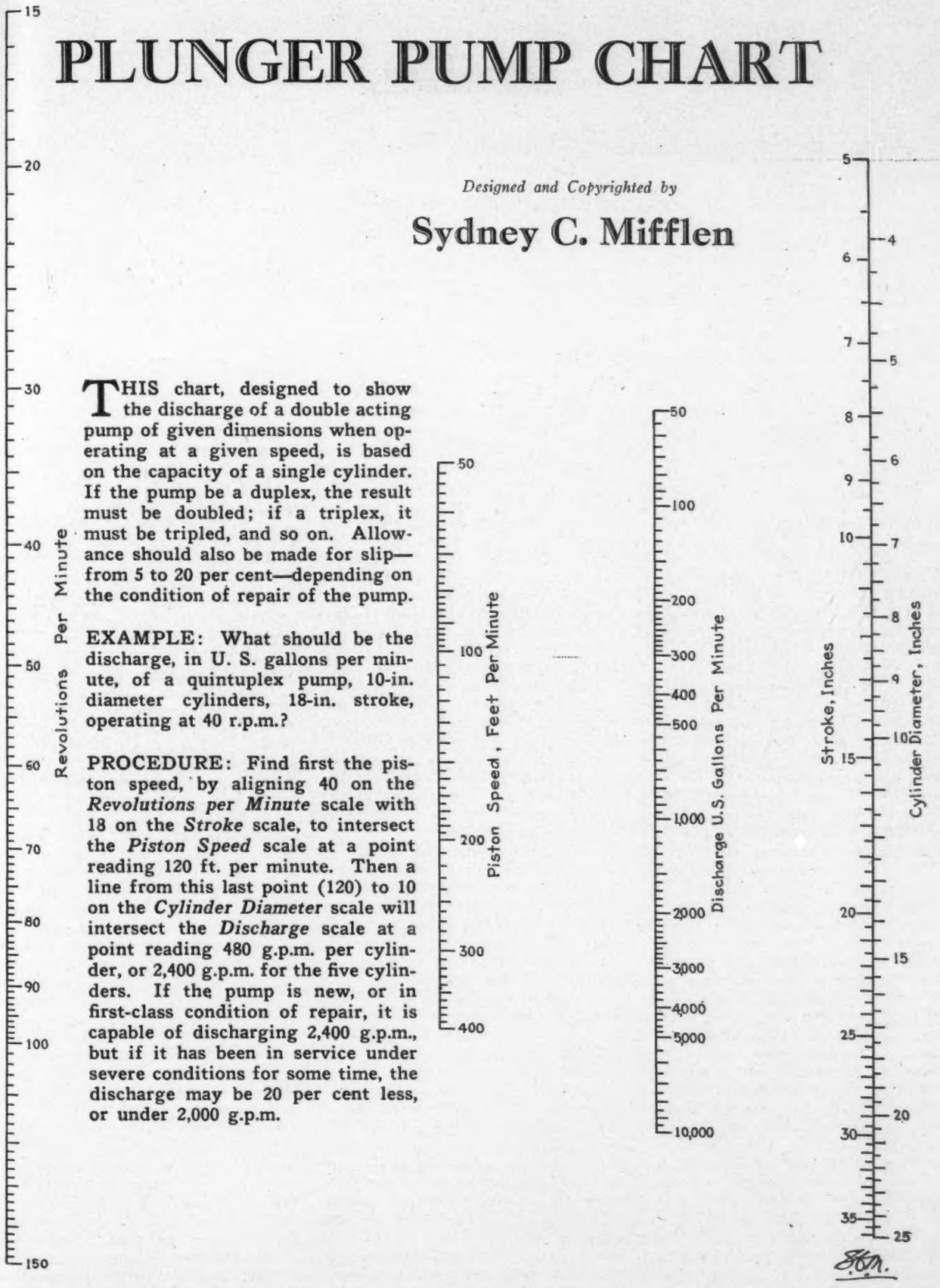
Designed and Copyrighted by

Sydney C. Mifflen

THIS chart, designed to show the discharge of a double acting pump of given dimensions when operating at a given speed, is based on the capacity of a single cylinder. If the pump be a duplex, the result must be doubled; if a triplex, it must be tripled, and so on. Allowance should also be made for slip—from 5 to 20 per cent—depending on the condition of repair of the pump.

EXAMPLE: What should be the discharge, in U. S. gallons per minute, of a quintuplex pump, 10-in. diameter cylinders, 18-in. stroke, operating at 40 r.p.m.?

PROCEDURE: Find first the piston speed, by aligning 40 on the *Revolutions per Minute* scale with 18 on the *Stroke* scale, to intersect the *Piston Speed* scale at a point reading 120 ft. per minute. Then a line from this last point (120) to 10 on the *Cylinder Diameter* scale will intersect the *Discharge* scale at a point reading 480 g.p.m. per cylinder, or 2,400 g.p.m. for the five cylinders. If the pump is new, or in first-class condition of repair, it is capable of discharging 2,400 g.p.m., but if it has been in service under severe conditions for some time, the discharge may be 20 per cent less, or under 2,000 g.p.m.



INDUSTRIAL PROGRESS

Alumina Cement Industry, Utilizing Bauxite, Offers Opportunity to Furnaces

MANUFACTURE of alumina cement in the United States would seem to offer attractive possibilities. Only about one-tenth of the world output of this commodity is produced and consumed in this country today, although the requisite raw materials and manufacturing facilities are available. This cement is especially valuable in construction work where the time required for setting is a factor of importance. It is, moreover, especially resistant to sea water and has special advantages in very cold waters.

A bulletin published in 1928 by the U. S. Bureau of Mines (Report of Investigation No. 2869) gave the results of tests made in a 6-ton blast furnace with the objective of producing alumina cement (slag) by smelting a charge of bauxite, limestone, iron ore, and cast-iron turnings. Here it should be borne in mind that though blast-furnace slag is utilized for making portland cement, the raw materials and technical details are different from those involved in making alumina cement. In the tests made the bauxite used ran 57.06 to 57.62 per cent Al_2O_3, about 2.76 per cent SiO_2, 16.32 to 16.77 Fe, 0.78 CaO, 0.48 MnO, and 2.64 to 3.08 per cent TiO_2. The limestone contained about 53 per cent CaO and 1 per cent SiO_2. Byproduct coke containing 75 per cent ash was used as fuel. The iron ore used ran 63.5 per cent iron.

On the basis of these tests, three estimates of the cost of producing alumina cement were made in this report. Using all scrap (no iron ore) in the charge, the total cost of producing 1 ton of alumina cement (not pulverized), valued at $30, and 1 ton of pig iron, valued at $20, was $25.95. With an all-ore burden, 1.6 tons of alumina cement, valued at $48, and 1 ton of pig iron, valued at $20, cost $31 to produce. With an ore-scrap burden, 1.1 tons of alumina cement (not pulverized) valued at $33, and 1 ton of pig iron, valued at $20, cost $26.15.

"This preliminary cost study," said the Bureau's report, "indicates that 1 ton of metal and 1 to 1½ tons of slag can be produced in the blast furnace for about $25 to $30, allowing no credit for surplus gas. If 1 ton of alumina cement is worth $30, and 1 ton of pig iron $20, the combined value of these two products would be $50, which leaves an attractive margin for grinding the slag, marketing costs, and profit."

One ton of iron was taken in the report as the unit for computing these costs. By crediting the iron produced to the cement, the cost of the latter, where its production is the principal objective, may be obtained. Pig iron at the moment is quoted at $17.50 to $18 per gross ton, Valley furnaces, depending on grade. In April, 1928, when the Bureau's report was issued, the price ranged from $17 to $17.50. If the cost of producing 1 ton of iron and 1 ton of alumina slag be taken at $27.50 (the average of the range given in the preceding paragraph for 1 ton of iron and 1 to 1.5 tons of cement), and the market value of the iron be taken at $17.50, the cost of 1 ton of slag—that is, of the unpulverized cement—would be $10. To this must be added the cost of grinding and packing the slag for market. If this be estimated at $1.50 per ton, the total cost of producing ground cement, as calculated, would be $11.50 per ton, or $2.12 a barrel. If more than one ton of slag were produced per ton of iron (for $27.50), the cost of the slag, or cement, would be correspondingly lower. Any credit for surplus gas would reduce the cost still further. Objection on the part of iron makers to increasing the amount of slag per ton of iron, equivalent to reducing the yield of iron, would be offset by the consideration that the iron in this instance is a byproduct.

At present (Nov. 18, 1930), alumina cement is selling at $8.50 to $9 per barrel delivered on the job, including sacks. This price would leave an ample margin for an attractive profit after all remaining charges have been made. Such an opportunity for profit appearing to exist, one may wonder why capital has been so slow to enter the new industry. Such difficulties as there may have been with respect to patent rights (for the manufacture of alumina cement has such protection) have been removed, according to E. C. Eckel, a patentee. Outlining the patent situation in a recent issue of *Manufacturers' Record*, he says:

"The Spackman patents of 1912, which described no process but did ostensibly at least cover the product itself, have been extended until June, 1935, under a very special act passed in 1928. The Eckel patents of 1924-25-26 are freed by agreement from any possible subservience to these Spackman patents, so that no one need fear patent litigation if he takes up the manufacture of alumina cement under license in a furnace, with incidental recovery of pig iron, high-silicon iron, or even ferrosilicon."

Mr. Eckel states, moreover, in a letter to *Engineering and Mining Journal*, that to make an alumina cement of absolutely high quality and steady grade, and at a cost which will permit its sale at, say, $2 to $3.50 per barrel anywhere in the United States, the process used must be one which can utilize low-grade bauxite and produce iron or ferrosilicon as a byproduct. To do this requires two appliances:

1. A furnace capable of developing melting temperatures. Any iron or copper blast or smelting furnace, any open-hearth furnace, any electric furnace, will do. An ordinary foundry cupola can be rigged up to produce good alumina cement. Obviously, a better appliance with larger output, hearth capacity and draft is more economical. (Every blast-furnace plant, every steel mill, every copper or other metal-smelting plant or refinery in the United States already has this very essential part of an alumina cement plant, representing about half of the total investment needed.)

2. Grinding and packing apparatus for the finishing of the cement, as in making portland, natural, or slag cement. (Every portland, natural, or slag cement mill in the United States already has this other essential part of an alumina cement mill.)

"In adapting the process to other than iron furnaces," says Mr. Eckel, "each case will have to be worked out separately for chemical composition. We seek to make a slag carrying 35 to 50 per cent lime, 35 to 50 per cent alumina, and less than 15 per cent silica. This last is, after all, the main requirement, for if the silica runs above 15 per cent, the cement is no better than portland and would have to be sold at

portland prices, say 10 per cent over actual cost. So any smelting plant which can keep down silica in its slag can adapt this process in some manner. And, inasmuch as at present rates the profits should be very large, it can go to a good deal of trouble to keep the silica down.

"In iron there is an additional curious feature. Because of the large amount of slag made, and its alumina-lime composition, the process is the most efficient desulphurizer known. You can use ores carrying several per cent of sulphur and still get pig irons with only traces of sulphur remaining."

An alumina cement industry should find favorable conditions in the South, where the greater part of the domestic bauxite resources of the United States occur. Under present conditions much of this bauxite is unsuitable for the manufacture of aluminum, so that the growth of an alumina cement industry that could make profitable use of them would speed their development considerably.

■ ■ ■

Mine Car Design Improved—Other New Equipment

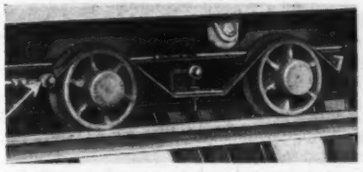


Fig. 1—Construction of this brake is said to insure equalization of braking pressure on all wheels with a minimum number of parts

Accompanying cuts show certain improvements recently made in car design by the Sanford-Day Iron Works, Knoxville, Tenn. Fig. 1 shows a brake, wherein the force is first delivered to the band of the nearest wheel. The tightening of this brake band automatically swings the pendulum between the two wheels, so that a braking force equal to that on the nearest wheel is automatically switched over to the farthest. Thus equalization of braking pressure is secured on all four wheels with the minimum number of working parts.

The company's so-called "Ten Year" wheel is shown in Fig. 2. No part of the wheel casting except the tread is subject to wear. This is true also of the locking pin. All end-thrust surfaces are inside the grease chamber, and the end-thrust pieces are removable and cheap. The bearings are well sealed against entrance of dirt and leakage of lubricant. Greasing once in every four to eight months is said to be sufficient.

Fig. 3 shows the so-called cantilever-construction car used for rotary- or end-dumping. The crosswise cantilever structural members at each end of the body rest upon and are attached to the rectangular structural-steel truck frame. They easily carry the entire weight on the flare. Attached to the cross-cantilever beams at the corners are the structural-steel side-supporting truss members running from end to end of the body. These are amply strong for all contingencies.

Fig. 5 shows the company's "Saw-Tooth" end-dump cantilever car, which is made in a wide range of capacities. This car dumps, like any other end-dump car, over either a crossover, a kickback, or an ordinary horn dump. Its features include an inclined floor reaching below the axles, a flexible rectangular frame construction, a pan-type floor, armor-plate bumpers, offset bumpers, and low, flaring side wheels, combined with a floor that lies below the axles. The end-gate construction is patented. This increases the load-carrying width of the car by about 3 in. and protects the front side of the car from spreading pressure.

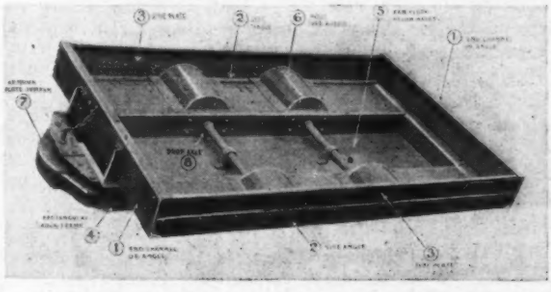


Fig. 3—Car of "cantilever construction" for rotary or end dumping

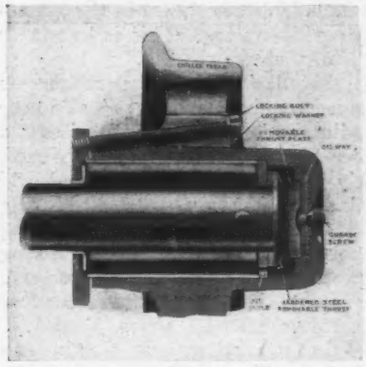


Fig. 2—An improved wheel for mine cars

Sealed-sleeve Motor Bearing Has Advantages

Many of the best insulating materials may be damaged by excessive heat and by lubricant. Artificial ventilation is often used to prevent the accumulation of excessive heat. J. L. Brown, mechanical engineer for the Westinghouse Electric & Manufacturing Company, points out that it is just as essential to prevent the escape of oil from the bearings on to the windings, and that this must be done in face of the fact that the flow of ventilating air tends to draw oil vapors from the bearing housing and deposit them on the insulated surfaces.

The design of motor bearings prevents an especially difficult problem, says Mr. Brown. The problems peculiar to such bearings are associated almost wholly with the housing design. In most applications, the type of bearing used will be immaterial if the housing is correct. The housing must support

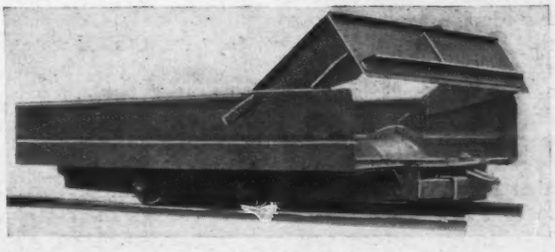
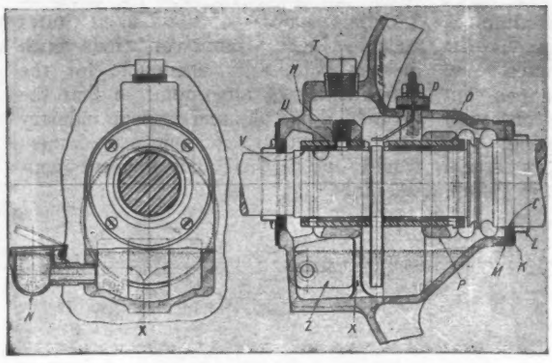


Fig. 4—An end-dump car of cantilever construction



Problems associated with housing design are said to have been overcome in this sealed-sleeve motor bearing. See text.

the bearing adequately, must prevent entry of foreign matter, and, most difficult, must prevent escape of lubricant. A housing in which effective measures have been taken to prevent oil leakage and exclude dirt is shown in the accompanying illustration. This is known as the "sealed sleeve bearing."

In this design adequate support is provided for the bearing at *P*. To keep out dirt and retain the lubricant a washer of soft resilient felt, *K*, is used, closely girthing the shaft at *C* and held in place by the pressed-steel bearing cap *M*. This cap has an overhanging lip portion, *L*, with a small running clearance on the shaft at the outer end. These parts have proved efficient for the purpose stated. Parts *T* and *D* close the inspection hole tightly and rigidly, as well as the slot for inserting the oil ring. Cored channel, *O*, balances the air pressure between the chambers of the housing. The pressure-relief groove, *U*, in the bearing prevents the oil from squirting under high pressure through the space between the bearing bore and the shaft, as at *V*. *H*, the dowel screw, does not extend through to the exterior of the housing, and oil leakage therefore cannot occur at this point. The threaded engagement of the overflow gage, *N*, with the housing, is sealed by oil-proof cement. This gage communicates with the oil reservoir in a quiet oil chamber, *Z*, partly separated from the main chamber by partitions, *X*. The partial isolation of this chamber also permits settling of any sediment present, thus keeping it from circulating through the bearing.

New Air-driven Sump Pump Introduced

An air-operated sump pump, known as the Quimby, has been introduced by the Chicago Pneumatic Tool Company, New York. This is a new device, operated by compressed air, that may be supplied by any portable compressor. The pump is driven by a No. 88 rotary air motor, and is strongly built, although weighing but 44 lb. Its capacity is 100 gal. per minute at 28-ft. head. With it the manufacturer claims that steady capacity may be obtained up to 50-ft. head.

Lift Truck Is Powerful

An electric lift truck for use with hand-truck platform skids, 7 in. high or over, has been developed by the Crescent Truck Company, Lebanon, Pa. This truck has been developed to fit

A lift truck with a turning radius of 7 ft.

into a field between the larger and heavier trucks and the ordinary truck of the hand-lift type. Its capacity is 3,500 lb.

■

One Use for Stills

In listing the various types of equipment likely to be used by a mining company, many would overlook the water still. Formerly, if this were used at all, such use was largely confined to the laboratory. Today, however, distilled water is required wherever storage batteries are employed, and owing to the widened application of the latter, a corresponding increase in the use of stills has taken place.

Inasmuch as mines are often situated in remote localities, they find it decidedly advantageous to be able to produce their own distilled water, as needed. Where the quantity of water required is large, it is decidedly cheaper to make it on the premises than to purchase it. It should be borne in mind, moreover, that boiler or turbine condensate contains many impurities and is no substitute whatever for pure distilled water, Home-made stills are likely to be inefficient and troublesome. Storage batteries are expensive and, on this count alone, it will be good economy for a mining company to make the small investment necessary to acquire an efficient still for providing the water needed.

BULLETINS

Grinding—Williamson Company, 582 Market St., San Francisco, Calif. Bulletin No. 30, "The Williamson Mill."

Covulc—Hitchcock Company, 48 Pearl St., Boston, Mass. A self-vulcanizing rubber compound.

Water Stills—Barnstead Still & Sterilizer Company, Inc., Forest Hills, Boston, Mass. Catalog B. Automatic water stills.

Air Separator—Raymond Bros. Impact Pulverizer Company, 1315 North Branch St., Chicago, Ill. Mechanical air separator.

Density Valve — Thyle Machinery Company, 129 Fremont St., San Francisco, Calif. Bulletin No. 60, on automatic control of underflow.

Brunton Transit—William Ainsworth & Sons, Inc., 2151 Lawrence St., Denver, Colo. Wilson magnetometer attachment.

Electric Furnaces — Ajax Electrothermic Corporation, Trenton, N. J. Bulletin No. 6, motor-generator type furnaces and equipment.

Feeders — Stephens-Adamson Manufacturing Company, Aurora, Ill. Manganese steel feeders.

Thermometers—Leeds & Northrup Company, 4901 Stenton Ave., Philadelphia, Pa. Catalog No. 80, resistance thermometers.

Rubber Linings—American Hard Rubber Company, 11 Mercer St., New York. Protection for chemical process industries.

Boiler Plant—Combustion Engineering Corporation, 200 Madison Ave., New York. Fin-tube type economizer.

Welding — Fusion Welding Corporation, 103d St. and Torrence Ave., Chicago, Ill. Bulletin No. 6.

Pump Cars — Western Wheeled Scraper Company, Aurora, Ill. Catalog No. 80, pump cars and grading equipment.

Compressors — Sullivan Machinery Company, 400 North Michigan Ave., Chicago, Ill. Bulletin No. 83-X, "WG-6" belt-driven, single-stage.

Valve Control — Brown Instrument Company, Philadelphia, Pa. Bulletin No. 7520, de Florez remote manual system of control.

Shop Hoist — Ambold Machine Tool Company, 50 Church St., New York. Demag junior hoist.

Centrifugal Compressors — General Electric Company, Schenectady, N. Y. Bulletin No. GEA-1280.

Milling Equipment—Morse Brothers Machinery & Supply Company, 2900 Broadway, Denver, Colo. Thirty-two pages.

Flotation — Denver Equipment Company, 1419 17th St., Denver, Colo. Bulletin No. 2901, entitled "Results in Modern Flotation," consists of 103 pages. The first fifteen pages are devoted to the following series of articles: "High Spots in Flotation History," by Charles E. Locke; "Reagents Used in Flotation," by A. M. Gaudin; "Testing Ores by Flotation," by C. S. Parsons; "Fundamental Conceptions of Flotation," by Arthur J. Weinig and Irving A. Palmer; "Flotation Theory," by A. W. Fahrenwald.

NEWS OF THE INDUSTRY

Rioting Causes Suspension at Cerro de Pasco

Rioting, which started on Nov. 12, has forced a complete suspension of operations at the Cerro de Pasco Copper properties, in central Peru. All Peruvian employees have been forced to leave the mining district and are now in Lima. However, the pumps at the mines are being kept in operation by Peruvian employees. This will permit resumption of production as soon as the disturbances have been quelled. How soon that will be is not known.

Some trouble was experienced at the Cerro de Pasco mines in September, following the revolution in Peru that resulted in a change of government. This disturbance was soon quieted with the aid of the new government and it incurred the loss of only a few days of operations at the Cerro mines. The other mining units and the Oroya metallurgical and power plants were not disturbed.

Cerro de Pasco operates the Cerro, Morococha, Casapalca, and Colquijirca groups of mines, of which the first two produce copper ore; the third, lead-zinc ore; and the fourth, silver ore. In addition, it has a copper property under development at Yauricocha. Location of these properties is indicated in the accompanying map. The company's production in 1929 was 49,993 tons of copper, 16,000,000 oz. of silver, 19,789 tons of lead, and 15,150 tons of zinc in concentrate.

■

Inco Orders New Frood Hoist

International Nickel has recently placed another order with Nordberg Manufacturing for a new double-drum hoist, to be installed at the No. 4 shaft of the Frood Extension nickel-copper property, in the Sudbury district of Ontario. This shaft was the one sunk by Mond Nickel to develop its share of the Frood orebody before the consolidation of the two companies. The new hoist will be driven by a 2,200-hp. direct-connected motor, will have 12-ft. drums and an 8-ft. face, and will be able to operate to a depth of 4,100 ft. Hoisting cable will have 1⅛-in. diameter. Equipment of this shaft will make it available for ore hoisting. At present, all Frood ore is hoisted through No. 3 shaft.

■

U.V.X. to Explore Vulture

Work on sinking a 500-ft. three-compartment shaft at the Vulture mine, near Wickenburg, Ariz., has been started by United Verde Extension, which has taken the property under option. Recent diamond drilling by the Vulture company, under the direction of D. R. Finlayson, president, is stated to have discovered the extension of the orebody from which a large gold production was formerly obtained, but which was lost through faulting. The ore was cut at a depth of 425 ft. and is stated to have been 40 ft. wide.

■

Southeast Missouri Mines Reduce Lead Output

Effective Nov. 1, the operations of St. Joseph Lead and St. Louis Smelting & Refining in the southeast Missouri lead district were curtailed 20 per cent. These two companies have been responsible for the entire output of the district since St. Joseph absorbed Desloges Lead last year. St. Louis Smelting & Refining is a subsidiary of National Lead.

Normal production from southeast Missouri is about 200,000 tons of lead annually. A 20 per cent reduction would mean a cut of 40,000 tons annually, or about 3,400 tons a month.

Cerro de Pasco holdings in Peru

Goldfield Exploration Continues

At Goldfield, Nev., development work is being continued by the only two operating companies in this once productive gold district. Goldfield Deep has completed repairs to its main shaft, overhauled the pumps, replaced more than 1,000 ft. of 24-in. ventilation pipe, and started sinking from 2,100 to 2,700 ft. Pittsburg-Goldfield Mining has sunk its new three-compartment shaft to 350 ft. and is now putting in an extra set of bearing timbers to support shaft timbering.

Granby Con. Closes Allenby Unit

Granby Consolidated, which has been curtailing operations at its Copper Mountain mine and Allenby concentrator, near Princeton, B. C., shut down these plants completely on Nov. 15. Though the company has announced that it is producing copper from its several mines at a consolidated cost of 9c. per pound, it has been no secret that the cost of production at Copper Mountain is appreciably more than that at Anyox, and, therefore, Copper Mountain must have been operated at a loss during recent months. In 1929, it produced about 930,000 tons of ore, or 12,000 tons of copper.

At Copper Mountain Granby has to buy power for the operation of mining and milling machinery, and treatment is taken only to the stage of concentrate. Moreover, the property is situated inland, necessitating rail transportation to the Tacoma smelter. At Anyox, on the other hand, the company has its own hydro-electric plant, which provides power for all purposes for about ten months in the year, and in mild winters for the full year; its own coal mine to provide feed for the coke ovens; and treatment is taken to the blister copper stage. The blister is refined at Sudbury, Ont., and the company probably gets some of the advantage of the higher market price of copper in Montreal than in New York.

Five men were killed and ten injured in a rock-and-mud slide that completely demolished the Granby boarding house at its Bonanza mine, near Anyox, on Nov. 11. The boarding house has accommodation for 85 men, though only 60 were in residence at the time and more than half of these fortunately were on the day shift when the slide took place. The slide followed some five days of unsually heavy rain, which presumably loosened the ground on the hillside above the boarding house, which was comparatively new, having been in use for less than two years.

■

Noranda to Handle Larger Proportion of Gold Ore

A larger proportion of its daily tonnage will be drawn from the orebodies carrying comparatively high gold content and low copper content, J. Y. Murdock, president of Noranda Mines, operating near Rouyn, Que., has announced. This step is being taken because of the low price of copper at present. No. 20 orebody, recently opened on the 1,500 level, contains a large tonnage of ore carrying as much as $15 and $20 a ton in gold. Production of gold will be about $300,000 monthly, which will put the company among the largest gold producers in Canada. This increase in revenue is expected to make up for part of the decrease in the value of the copper output. Noranda has been producing about 6,500,000 lb. monthly.

Visitors to manganese convention assembled at the Hotel Mayflower, in Washington

Manganese Producers Association Holds Meeting in Washington

A YEAR AGO, the assurance of tariff protection for United States manganese production would have seemed to leave those having money invested in manganese mining enterprises with no other concern than to build up production to the best of their ability, all ordinary difficulties considered. Today, with the tariff question settled, for a time at least, new worries have been precipitated by the fall in the world price of ore to a level where the existing tariff affords no effective protection. This drop in price being attributed by some to "dumping" of Russian ore, the evils of dumping and the status of the Russian five-year plan supplied a theme for discussion at the annual convention of the American Managanese Producers' Association in Washington on Nov. 10 and 11. A petition for an embargo against the importation of Russian manganese was filed with the Treasury Department by the Association on Nov. 11. Optimism that the decision of the Department would be favorable to their interests seemed to prevail among those responsible for the petition. Moreover, word from Senator Tasker L. Oddie, of Nevada, hitherto a staunch partisan of the domestic producers, was received, to the effect that he intended to introduce in the next Congress a bill calling for the embargo.

Communist activities likewise furnished the topic for the speakers at the annual banquet. James W. Gerard was toastmaster. The speakers were Representative Hamilton Fish, Jr., chairman of the Congressional Committee that is investigating Communistic activities in the United States, and Dr. Edmund Walsh, of Georgetown University.

Another portrait of the Soviet government was presented at one of the four sessions, by A. A. Djakeli, president of the Société Industrielle Internationale Fagbagan, a French company, which, according to the speaker, legally owns the Tchiaturi manganese mines in the Caucasus, although its rights and properties have been seized by the Soviet. Mr. Djakeli discussed the history and present status of the Georgian (Caucasus) manganese situation.

The general topic of this session was "The World Manganese Situation." The very latest statistics on the world situation in manganese in 1929 were presented by Louis A. Smith, of the U. S. Bureau of Mines. Of the 2,579,000 long tons of manganese ore exported by the five leading nations in 1929, India exported 37 per cent; Russia, 34; Gold Coast, 16; and Brazil, 11. Of the 2,693,000 tons imported by the seven principal consumers, France took 28 per cent; the United States, 25; German, 14; Belgium, 4; United Kingdom, 11; Norway, 6; and Italy, 4. The United States also imported a large quantity of ferruginous manganese ore and manganiferous iron ores from Spain, Greece, North Africa, India, Sinai Peninsula, Australia, and Brazil. This was used for making spiegel and manganese pig iron, and for mixing with high-grade ore in making ferromanganese. Observations as to conditions in Russia, made on a recent trip to that country, were also presented at this session by Jess Briegel.

A general survey of the domestic manganese situation was afforded at the opening session by members from different parts of the United States, speaking informally. After the Association's president, J. Carson Adkerson, had welcomed those present and painted a sweeping picture of conditions, W. B. Daly, general manager of mines for the Anaconda company, told of the successful work done by his company in floating the low-grade rhodochrosite ores of Butte. By it the reserves of workable manganese ore in Butte had been increased by four or five times, he said. The concentrate had been nodulized by Domestic Manganese & Development, sold to Colorado Fuel & Iron, and made into ferromanganese at the latter's Pueblo plant. There was no market at present, however, and Anaconda's manganese mining operations, and the calcining work of the Domestic company, had ceased (save for the shipment of some low-grade ore by Anaconda directly to Colorado Fuel & Iron).

E. S. Clark, representing the Chapin Exploration Company, of Nevada, said that the company's plan to erect a plant had been temporarily abandoned, although its visible reserve had been increased. E. A. Fritzberg, manager of the Trout mine, at Philipsburg, Mont., and John Hickey, of Moorlight Mining, in the same camp, said that operations there were affected by the prevailing depression. Charles A. Massie, of Woodstock, Va., briefly summarized the results obtained in the Hy-Grade company's new 100-ton plant. Among the other speakers were O. Stange, with a property in Virginia; a representative of the Interstate Ore & Metals Company, North Carolina (near Murphy); W. R. Spencer, of New Mexico; and William Kemmler, of Johnson City, Tenn.

Hon. F. H. Payne, Assistant Secretary of War, and Major A. H. Hobley, of the War Department, spoke on industrial preparedness in its relation to essential minerals at the following session. Dr. Oswald N. Schreiner, of the Department of Agriculture, presented the latest facts regarding the use of manganese to stimulate plant growth.

Discussion of new beneficiation processes marked the closing session. R. S. Dean summarized the work done by the Bureau of Mines to determine whether low-grade ores could be concentrated to make ferro or spiegel; whether ferro could be produced directly by pyrometallurgical means; and to determine the possibilities of hydrometallurgical means. By concentration alone, he said, it seemed likely that some 300,000 tons of manganese could be provided annually. The Bureau, he said in closing, had developed a new iron-manganese-silicon alloy that would enable the steel industry to produce a cleaner steel.

Wilson Bradley said he had modified his leaching process by taking CO_2 from the furnace stack and using it with NH_3 to precipitate $MnCO_3$, which filtered, settled and washed better than the MnO,OH formerly precipitated.

Adrian Nagelvoart, of the Delaware Chemical Engineering Company, Wilmington, told of progress made with heavy-liquid separation, using acetylene tetrabromide. A separator had been installed at the Silver Prince plant, in Philipsburg, Mont., using a 2.8 specific gravity liquid on ore crushed to minus half-inch size. A concentrate running 54 per cent manganese and 5.7 per cent silica had been obtained, the tail running 20 per cent manganese and 40 per cent silica. Loss of liquid had been reduced to a few ounces per ton of ore treated, he said.

The Business Meeting

James W. Gerard was elected chairman of the Association's board. C. K. Woodbridge, president of the American Machine & Metals Company, and Judge E. S. Clark were added to the directors. W. B. Daly, of the Anaconda Copper Mining Company, was elected second vice-president, and L. L. Savage, third vice-president. Other officers were re-elected.

■

Inco Votes Unemployment Fund

The board of directors of International Nickel has authorized the expenditure of $100,000 as a measure for unemployment relief, most of which will be spent in the Sudbury district of Ontario, where its copper-nickel properties are situated. From 700 to 1,000 men are estimated to be unemployed in the district. Many of these were formely employed on construction work and others have been discharged as part of the company's curtailment policy at the Frood mine and Copper Cliff smelter. A program of civic improvement for the town of Copper Cliff will be started.

Drilling at Chino Adds to Nevada Con. Reserves

Drilling done on the southern extension of the Sierra orebody at its Chino property, Santa Rita, N. M., has added about 30,000,000 tons of ore to the reserves of Nevada Consolidated since the beginning of the year. Work on this area was started in August, 1929, and by Jan. 1, 20,000,000 tons of better than 1 per cent copper had been proved. The total new tonnage in this area, nearly all of which can be mined by steam shovels, is therefore about 50,000,000 tons, averaging 1.5 per cent copper. As Chino normally handles between 3,500,000 and 4,500,000 tons of ore annually, this discovery apparently makes it possible for the company to delay considerably the starting of underground operations through the Estrella ore shaft. At present the shaft is being used for development work only.

Ore reserves at all Nevada Consolidated properties at the end of 1929 totaled 273,500,000 tons. Less than 6,000,000 tons has been extracted so far this year, indicating that the addition at Chino brings reserves close to 300,000,000 tons.

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The Consolidated smelter at Trail, B. C., where a new fertilizer plant is under construction

Mining Revival at Tucson Attracts Arizona Miners

Executives, mining engineers, operators, and prospectors attended in full force the fifth Arizona Mining Revival, held in Tucson, Oct. 31 and Nov. 1. The meeting was sponsored by the Tucson Chamber of Commerce, under the direction of A. J. Harshberger, president, mines department; the Arizona Industrial Congress; and the Arizona chapters of the American Mining Congress and A.I.M.E., to stimulate interest in the future of mining and its relation to Arizona.

The sessions, at which valuable and instructive papers were read, were held at the Safford High School auditorium. Frank J. Rucker, president of the local Chamber of Commerce, opened the convention with a speech of welcome, after which P. G. Spilsbury, president of the Arizona Industrial Congress, in a well-prepared paper pointed out to the audience the importance and benefits to the state derived by mining, and urged that development work be continued in present times. Other speakers and their subjects were: J. B. Tenney, "History of Mining in Pima County"; Hugo Miller, "How to Prepare a Prospect for Presentation to an Examining Engineer"; Mose Drachman, "Prospectors I Have Grub-Staked"; Monte Mansfield, "Auto Versus the Burro"; Robert E. Heineman, "Non-Metallics and Rare Minerals"; John B. Wright, "Prospectors' Legal Rights"; T. W. Quayle, "Big Trees From Little Acorns Grow"; G. M. Butler, "Service Available to the Prospector from the Arizona Bureau of Mines"; and J. J. Jakosky, "Demonstration of Electrical Prospecting With Experience on Recent Properties Tested." Ensuing discussions were lively and interesting. T. H. O'Brien, Jack O'Dowd, and Howard H. Fields presided at the various sessions.

On Friday the delegates were guests at a luncheon tendered by the Kiwanis Club, at the Hotel Santa Rita; and in the evening a barbeque, with musical attractions, ended the first convention day. The Saturday session was closed with a demonstration of safety appliances and first-aid work, given by the first-aid team of the local branch of the Mountain States Telephone & Telegraph Company, under the direction of H. F. Drown; and the presentation of silver cups to Mrs. Bertha Jaeger, for partaking in mining activities the past 25 years, and Thomas Bentley, age 72, for being the oldest prospector in Arizona. The trophies were presented by Dr. E. P. Mathewson and A. B. Richmond, ore buyer, Magma Copper Company. Thereafter the delegates attended a luncheon given in the University dining room, which was followed by an inspection of the Mines building, laboratories and Arizona State Museum —reserving ample time to witness the Arizona-Pomona football game.

■

Yukon Official Reports on Mining Activity

The mining industry in the Yukon Territory, Canada, is moving on steadily and hopefully, according to G. I. MacLean, gold commissioner of the territory.

Though the present low prices for silver, lead, and copper naturally have a tendency to slow up the work of prospecting for and extracting those metals, the silver mines of the Keno-Mayo group have ore of such high quality that they are continuing operations with no great change in the total output. Treadwell-Yukon is the principal operator in the district.

On the other hand, the relatively high price of gold has had the opposite effect on both placer and quartz mining for that precious metal. Quartz gold mines on the upper waters of Bonanza Creek have been worked for some time, but recently developments have led to greatly increased interest in the properties there, and important results are hoped for.

In the southern part of the territory, on Lake Creek, in Hootalinqua district, a new find of placer gold is reported. The area embraced in the original discovery has been thoroughly staked. The question of whether there will be any rush into the district will depend upon the results of prospecting on adjoining creeks, therefore. Dredging and hydraulicking operations for gold production this year compare favorably with those of the past few seasons.

Develop Wanderer With View to Increasing Capacity

Development work at the Wanderer Consolidated property, in the Selukwe district of Southern Rhodesia, is being pushed with a view to increasing ore reserves sufficiently to justify stepping up mill capacity to 1,000 tons daily. At present about 500 tons of ore, averaging 5.5 dwt. in gold per ton, is being milled daily at a monthly profit of £6,000. Present ore reserves are estimated at 650,000 tons, or about a four-year supply.

The Wanderer orebody shows every indication of continuing in depth, according to the management, but pitches to the south. It is now being developed on the No. 3, or 775, level. On the 500 or Adit level, a tunnel is being driven north along the ore channel with the intention of opening up other orebodies that outcrop on the surface. Drilling to locate the position of the Kemerton orebody at this level has been started, and later that of the Kemerton orebody will be ascertained.

■

Purchase Virginia City Claims

Los Angeles interests have purchased the Ophir claim of Ophir Mining and the California claim of Consolidated Virginia, in the Virginia City silver-gold district of Nevada. The two claims cover a large portion of the outcroppings of the old Comstock lode. On a leased block in the Ophir claim, ore of milling grade has been opened by Frank Erno, formerly superintendent of Consolidated Virginia. The purchase is subject to the lease during its life.

Ophir Mining, Consolidated Virginia, and Mexican Silver and Gold, all of which formerly operated in the Virginia City district and which are controlled by Zeb Kendall, are now at work in the Pinnacle mine, Cripple Creek, Colo. About two years ago, the Mexican took over the property and, after opening an oreshoot, leased part of the ground to the other two companies. On the No. 8 level, the Mexican is now in high-grade ore, from which a recent carload shipment returned about $100 a ton. The company has shipped 138 carloads in all. The Virginia and Ophir companies are drifting on the No. 6 level.

The new crushing unit at the Philipson tunnel of Climax Molybdenum, near Climax, Colo.

Teck-Hughes Preparing to Block Out Ore at Depth

Virtual completion of the mine-deepening program at the Teck-Hughes Gold property, Kirkland Lake, Ont., is permitting more extensive lateral development and blocking out of ore between the Nos. 21 and 30 levels. The new South shaft has been completed to a depth of 3,600 ft., has been connected with the Central shaft on the No. 25, or 3,000, level, and is now being connected with that shaft on the No. 30, or 3,600. level. Hoisting of ore has been started from the South shaft.

As the mine was well supplied with reserves of broken and blocked ore, no particular effort was made to break or block out more than sufficient to replace the tonnage treated during the shaft-deepening program, according to D. L. H. Forbes, general manager. Above the No. 21 level, ore broken or blocked out on three sides on Sept. 1 amounted to 576,289 tons of an average grade of $17.43 a ton. From the small amount of work done between levels Nos. 22 and 25 and diamond drilling in other parts of the mine, numerous indications of possible new ore and substantial increases to "partly developed" ore have been obtained.

The management feels confident that the increase in mill capacity to 1,250 tons of ore daily is justified by the continuation of ore at depth, in spite of the fact that fully developed reserves are not equal to more than two years of operation at the increased rate. At present 950 tons of ore is being treated daily. Provision is made in the program of mill expansion for additional fine grinding of the ore that will be delivered from the South shaft crushing plant to the 300-ton "old mill" unit. With this additional grinding, recovery at that unit is expected to be increased to that obtained in the 650-ton "new mill" now in operation. The "new mill" treated ore averaging $19.97 in gold per ton and recovered $18.89 per ton, or about 95 per cent.

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San Francisco Section Discusses Aviation

Aviation was the subject discussed at the November meeting of the San Francisco Section of the A.I.M.E. F. M. English, of the Curtiss-Wright Flying Service, talked about aviation and transportation applied to the mining industry. Mr. English took up in detail the developments in landing fields, airways, weather-reporting service, and the improvements in airplane construction and operation. He said that the mining business is particularly adapted to private-plane ownership. An airplane used safely and intelligently can be used 90 per cent of the time, but in the absence of accurate weather reports, bad weather makes it inadvisable to fly. He instanced the use of planes by mining companies, mentioning Bulolo Gold Dredging, which is planning to transport its dredging equipment by airplane, and the Wernecke mines, in Yukon Territory, where airplanes have been placed in profitable operation for shipping urgently needed supplies, for aërial surveying and prospecting, and for emergency travel in transporting sick and injured men.

W. L. Cozzens, assistant district manager, Fairchild Aërial Surveys, Inc., discussed some of the details of photographic mapping and its application to geological study. He showed a number of interesting studies and dilated upon some of the principles involved. He pointed out the use that might be made of aërial photography in detecting the courses of Tertiary river channels in the Sierra. Stereoscopic photography for use in contour work was briefly described.

Change Santa Isabel Plant to All-Flotation Concentrator

Remodeling of its 300-ton Santa Isabel mill, in Sierra Madrona, Spain, to make it an all-flotation plant is being undertaken by Penarroya, one of the largest European lead-zinc producers. The Santa Isabel unit has been treating complex lead-zinc-iron ore by jigging, tabling, and differential slime flotation. Recoveries have been low.

Having demonstrated the harmful effect of too much grinding on recovery, and the difficulty of making a separation between galena and sphalerite because of the presence of chalcopyrite, R. Barthelemy, who was formerly with the U. S. Bureau of Mines at Rolla, Mo., and who is now in charge of the concentration department of Penarroya, has designed a flow sheet in which all concentration is effected by selective flotation. A new reagent will be introduced to overcome the effect of chalcopyrite in the lead circuit. Mr. Barthelemy expects 86 per cent recovery of the lead content and 84 per cent recovery of the zinc.

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Boleo Retains Full Force

Reports that Compagnie du Boleo, French-controlled copper producer operating at Santa Rosalia, Baja California, Mexico, had discharged a large part of its working force are incorrect, according to R. Nopper, director of the company at the properties. To date, the only step that has been taken in this direction is a cut in wages, in conformity with the drop in the price of copper. Because of the depressed condition of the copper industry, the question of equipping the southern part of the property for copper production has been deferred. Ore deposits have been opened up in this section of the company's holdings which officials hope will be able to replace the orebodies now under exploitation when they are exhausted.

Michigan Amygdaloid Tailing May Be Worth Re-treating

Sampling of old amygdaloid tailing in the Michigan copper district has been in progress to determine what percentage of copper recovery might be expected from flotation treatment. The results are gratifying. All producing companies have considerable tonnages of these waste sands. Deposits on the shores of Lake Superior have been more or less scattered by storms, but a large volume remains, particularly in the more compact piles near land. Some of the copper in tailing near the surface has become oxidized, and recovery is somewhat less from this type. All sampling to date, however, apparently gives assurance that the millions of tons of amygdaloid tailings in the district form a potential source of copper, which can be reclaimed at a cheap and profitable rate when the market for copper warrants reclamation.

It is estimated that the sands can be treated at a cost of approximately 22c. per ton, including regrinding and flotation, and in many cases average recovery will be around 6 lb. per ton. Deposits far removed from operating mills can be treated in portable plants. Tailing from present operating mills can be run back through the flotation units.

At its Champion, Baltic, and Trimountain tailing piles in Lake Superior, and old Atlantic sands in Portage Lake, Copper Range probably has 10,000,000 tons or more available for treatment. Recovery, it is estimated, would be about 6 lb. of copper per ton.

Quincy, whose mills are located on inland Torch Lake, has about 30,000,000 tons at Mason and about three-quarters of a million tons at the old mill site on Portage Lake. It is estimated that from the top or oxidized portions of these deposits a recovery of about 6 lb. per ton can be obtained, while from the lower portions an 8- to 10-lb. recovery is possible.

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Ship Steadily From Bonanza in Bingham District

Shipments from the Bonanza lease on Park Bingham ground, in the Bingham district, Utah, which were started in August, will be put on a basis of two to three carloads a week, if the plans of the operators mature. The nine carloads for which returns have been received netted the lessees $11,750, or about $22 a ton, after transportation and treatment charges. Park Bingham has started shipments of comparatively low-grade lead-zinc ore on its own account. At present, the company's indebtedness amounts to $98,000. An assessment of 1c. a share has been levied to meet mortgage obligations.

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Coniaurum Bottoms New Winze

Coniaurum Mines, operating under the direction of Ventures, Ltd., has reached a depth of 2,500 ft. with a winze sunk as an extension of the main shaft from the 2,000 level of its mine at Porcupine, Ont. Lateral development work will be started at once at 2,250 and 2,500 ft. to open up No. 12 vein. This is one of the more promising veins on the property. Development of Coniaurum Mines was carried to a depth of 2,000 ft. by Coniagas Mines, Ltd., which abandoned the attempt about eighteen months ago to Ventures, Ltd., in consideration of the purchase of a block of treasury stock and an option on control at a sliding scale of prices. Out of a production of approximately $60,000 per month the mine has continued to defray operating expenses and meet development costs to date. The property is east of and adjoining McIntyre Porcupine.

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New Company Formed to Hold Rex and Red Monarch

Associated Mines has been formed by Spokane interests to take over the Delaware Mines holdings in the Cœur d'Alene district of Idaho, consisting of the Rex and Red Monarch claims. The Delaware company had planned driving the Red Monarch crosscut to the Rex vein and subsequent exploration along the vein for the Rex orebody. Lack of funds prevented the execution of this program. The new company expects to resume work in the spring.

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Official Assay Results Show Grade at Bannockburn

First official assay results from a small amount of trenching and pit sinking so far completed over a length of 130 ft. on the Bannockburn claims of Mining Corporation of Canada, in the Matachewan area, Ont., are now available. Because of the low, wet ground and the presence of water, it has been found impossible to locate the hanging wall of the vein, but according to official information the footwall section where exposed will average $50 a ton over a width of 2½ ft. The mineralized footwall country rock also carries gold for 2 or 3 ft. The company has decided to rush in a diamond drill with the first snow to explore the strike of the vein, before definite plans as to plant and future operations are completed.

More than 500 claims have been staked and recorded in the Montreal River and Gowganda mining divisions, with the Recorder's office at Elk Lake, Ont., since Oct. 1. The unusual activity is the result of the Ashley-Garvey find in Bannockburn Township, under development by Mining Corporation of Canada. An additional group of nine claims, located directly north of the discovery group, and staked by A. C. Mosher for United Prospectors' Syndicate, has been optioned by Mining Corporation.

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Ontario Refining Makes Record in Casting Copper

A casting record of 92 tons of refined copper per hour has been attained by Ontario Refining at Copper Cliff, Ont., through the use of two ladles pouring simultaneously into eight molds of a 40-ft. Clark casting wheel. As a result of curtailment of operations of International Nickel at Port Colborne, and later at the Copper Cliff smelter, operations at the refinery have also been substantially reduced. Output of refined copper, including the custom business from Granby Consolidated, is now less than 4,000 tons per month. The new acid recovery plant, designed for the recovery of nickel from the used electrolyte, is nearing completion, and will probably be ready to operate at the end of the year.

Opposition Develops to Chinese Silver Loan

The proposal made by Western Senators and mining interests that a loan of several hundred million dollars be made by the United States to China, in the hope that such a move would both stimulate the trade with the Orient and bring the price of silver back to its normal level of 50 to 60c. an ounce, has not met with unanimous approval in Washington. In some official quarters, the feeling is that such a loan would hurt, rather than help, the silver producers. These observers declare that China has too much silver now and that to dump more into the country would have the effect of depressing the price of Chinese silver and further reducing the country's purchasing power.

It is contended that there is nothing to justify a loan to China by the U. S. government. This can be left to the bankers, it is believed, who usually handle loans much more successfully than does a government. If the money is expected to stimulate purchases in this country, it would be much better to negotiate a dollar loan, it is said. It is contended also that what is needed in China is a stabilization of its money. The way to bring that about would be to adopt a plan under which China gradually would be brought onto a gold basis along the lines being followed in India. Another point made in connection with the proposed government loan, looking to the benefit of the silver industry, is that there would be demands for similar action to increase the demand for American wheat, textiles, and other commodities and goods. The government is in no position to undertake financial operations that in the aggregate might amount to a staggering sum.

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Broken Hill South Ending Construction Program

Reconstruction of the greater part of the mining and milling equipment of Broken Hill South, operating a lead-zinc mine at Broken Hill, New South Wales, Australia, will probably be completed at an early date, synchronizing with the completion of the new central power station, according to Colin Fraser, chairman of the board of directors of the company. The new No. 7 shaft has been completed to the 1,170 level, and work is now under way on the remaining section to 1,570 ft. Stations have been cut at 1,070 and 1,170 ft. The mechanical parts of the hoist that will be installed at this shaft will be supplied by Fullerton, Hodgart & Barclay, Ltd., of Paisley, Glasgow, and the electrical equipment is being manufactured by Metropolitan-Vickers, Ltd., of Manchester. No. 7 shaft will be used in development and production from the orebody at depth.

Most of the ore is now coming from about the 970 level. The mining program has been directed to extraction of the remaining blocks of ore in the northern, or older, part of the mine. At the same time, the southern section is being systematically developed for more extensive stoping in the near future than is now being done. Development work on the adjoining Zinc Corporation indicates that a large tonnage of ore is available in the Broken Hill South property, in addition to the estimate of 4,250,000 tons made in the annual report. Annual production is about 400,000 tons.

BRIEF NOTES

Amparo Mining. Operation of the company's three mines in Jalisco, Mexico, has been continued at the normal rate despite the drop in the price of silver, although profits have been adversely affected. The company has taken an option on the Pasadena del Monte and San Nicholas del Monte properties in Guanajuato. Engineers are now examining the properties.

Basin Montana Tunnel. W. H. Hax, president of the company, states that surveys have been started, preparatory to driving a 3-mile tunnel at its lead-zinc-copper property, near Basin, Mont. The company has been developing the Grey Eagle claim for the last two and a half years, and development results are said to have been sufficiently encouraging to warrant driving the tunnel.

Blue Frog Placer. A power shovel has been placed in operation at this property, near Oakdale, Calif. About 500 cu.yd. of gravel daily is loaded into trucks and transported to a bin, where it is screened and fed to sluices. The property is on the Stanislaus River.

Bunker Hill & Sullivan. The Imperial group, in the Galena district, near Battle Mountain, Nev., has been optioned by the company. Roy H. Clarke will be in charge of development work, which is to start at once. The deposit carries low-grade gold material in a quartzite schist formation. A crosscut tunnel will be driven to intersect the veins exposed on the surface.

Butte & Superior. Results of exploration at the mine at Butte, Mont., during the third quarter resulted only in the development of small but promising veins of zinc ore on the 1,600 and 2,500 levels. Under existing conditions, with low metal prices, these discoveries do not change the outlook for the future of operations. Closing of the Anaconda zinc concentrator has deprived the company of a market for its ore, and only a few unfinished exploration projects are now being continued.

Callahan Zinc-Lead. Development work on the 1,000 level of the Galena mine, in the Coeur d'Alene district, has resulted in opening up two sections of ore in the south vein, which has been explored on the 600 and 800 levels also. Both oreshoots were about 100 ft. long and the first one assayed 5.6 per cent lead and 4.4 oz. of silver over a width of 4.5 ft. Work has already been started on the 1,200 level.

Calumet & Arizona. The company, having completed its program of mill construction at Ajo, Ariz., is now operating the concentrator there on a five-day week, as, with the increased capacity, this schedule is sufficient to maintain production at the usual rate. The plant is now capable of handling 15,000 tons of ore daily.

Calumet & Hecla. Operations at the properties in Michigan have been put on a four-day-week basis. They had been previously reduced to a five-day week. The Lake Linden reclamation plants, which treat old tailing, are being shut down completely. Calumet & Hecla has been operating at a loss, after depreciation and depletion charges, because of the drop in the price of copper, and it has been forced to pass its dividend.

Hecla Mining. A crosscut is being driven on the 2,800 level of the property, in the Coeur d'Alene district of Idaho, to connect the lead-silver orebody that has been developed on that level with the main shaft. All production below the 2,000 level is now being handled through a winze. Direct connection with the main shaft is expected to reduce operating costs. Production of the property has been curtailed somewhat because of low metal prices. At its Union mine, north of Grand Forks, B. C., additional ore has been encountered and a good profit is being earned. About 150 tons of gold-silver ore is being produced daily.

Hugget-Hoffman Mines. This company has taken over the Black Rock, Mint, and Moon Flower placer claims, on Oak Creek, in the Walnut Grove district, 25 miles south of Prescott, Ariz. Operations will be conducted under the direction of Victor Hoffman, vice-president and manager of the company. Col. C. W. Steinman, of Tucson, will be consulting engineer.

Kernick Divide Mining. The ore bins of the new 50-ton mill at Sodaville, Nev., are being filled, and operation is expected to start on Nov. 25. The mill is about 3 miles from the mine, ore being hauled in motor trucks. Gold is the chief metal constituent of the ore. The new mill includes an 8x15-in. Wheeling jaw crusher, a No. 54 Marcy ball mill in closed circuit with a Dorr simplex classifier, Kraut flotation machines, a Deister Plat-O table, and an Allen cone.

Mercury Corporation of America. The company's plant at the Rinconda mine, San Luis Obispo County, Calif., was totally destroyed by fire on the night of Oct. 31. An entirely new plant, electrically driven, is now being built under the direction of E. J. Bumstead. Mr. Bumstead recently designed and erected a similar mill and furnace for the B & B Quick mine, in Nevada.

Moore-Buckskin Corporation. Work has been started at the South Jackson property, near Jackson, Calif. The company is unwatering the shaft, now 578 ft. deep. Crosscuts will be driven at various levels to explore the property. An agreement has also been concluded with the Central Land Company for the purchase of the Moore Mining property, near Jackson.

Mount Lyell. The tonnage of copper ore handled in the company's concentrator, on the West Coast of Tasmania, Australia, has been stepped up to 700 tons daily. Capacity is being increased to about 1,000 tons to permit treatment of low-grade ore from the Tharsis orebody. About 200 tons of ore daily is now coming from the Lyell Comstock mine. Steady progress is being made in construction work. The new cells for the electrolytic refinery are now being installed.

Mountain Copper. Mining operations at the properties at Iron Mountain, Shasta County, Calif., are on a reduced basis. The company is shipping sulphide ore to chemical plants near San Francisco and has completed extensions to the cyanide plant. The capacity is now 600 tons of low-grade gold-bearing gossan material daily.

Pend Oreille Mines & Metals. The company has taken a lease on the 300-ton Grandview mill, in the Metaline Falls district of Washington, and plans shipping ore to the plant from its near-by properties by means of a cable tramway across the Pend Oreille River. Pend Oreille will pay $1,000 monthly for the use of the plant and will make any necessary enlargements. The lease will run two years. Both Grandview and Pend Oreille have been engaged in developing low-grade lead-zinc deposits near Metaline Falls for the last three years. The Grandview mill was built in 1928 and was operated by the company early in 1929, but was forced to shut down because of low metal prices. Pend Oreille announced ambitious plans in 1929 for construction of a 2,000-ton mill and electrolytic zinc plant to treat ore from its own mine as well as the Reeves-McDonald mine, which it controls in British Columbia.

Penn Mining. A company is being organized by S. M. Levy, who was in charge of development work at Calaveras Copper for Engels Copper, to take over the Penn Mining holdings at Campo Seco, Calif. The property formerly produced copper, silver, and gold.

Potgietersrust Platinum. Because of the low price of platinum, the flotation section of the concentrator at Rustenburg, Transvaal, South Africa, suspended operations in August. Production is now in the form of crude platinoids, sent to England for refining. The chlorination plant near Johannesburg also closed down after treatment of the accumulated concentrate had been completed. Both plants will be able to resume work whenever the platinum price improves. Capacity of the concentrator is 6,000 tons of sulphide ore monthly.

Seneca Copper. A further reduction has been made in the company's underground force and wages have been cut 10 per cent. Production is now only about 300 tons of ore daily from the mine, north of Calumet, Mich. No stoping is being done. In No. 1 shaft, development work is being started on Nos. 12 and 13 levels as stations have been completed.

Seven Troughs Gold. Production at the property, near Lovelock, Nev., has evidently been stabilized at about $50,000 in gold monthly, the returns for the first three months of operation indicate. In October, output was $48.935 from 2,785 tons of ore averaging $18 a ton, compared with September output of $53,000 from 2,830 tons, and $48.254 in August. A crosscut has been driven to the vein from the tunnel at a point 4.400 ft. from the portal. As the crosscut is only 450 ft. long, about 1,500 ft. of tramming will be saved by hauling most of the ore through the crosscut instead of through the drift along the vein.

Skycomish Copper. Operations of this property, in Skycomish County, Wash., have been shut down for the winter. The rainy season set in before completion of road construction and transportation of winter supplies to the property is now impossible. William Sharpe, superintendent of the property, has returned to Reno, Nev.

Tonopah Extension. During October the company produced 132,380 oz. of silver-gold bullion from its mine near Tonopah, Nev. The value of the bullion was placed at $70,200. In September, bullion production was put at $67,900. Extensive development work is being continued, but production is now regulated to meet expenses only, as the management prefers to conserve its ore reserves for better silver prices.

Ontario Gold Production at Record Levels

Cumulative production of gold from the mines of Ontario for the ten months ending with October totaled $29,254,756, as compared with $27,783,533 for the corresponding period in 1929. Preliminary estimates, on the basis of these figures and providing for additional output from Lake Shore and Dome Mines in the last two months of the year, indicate that the total output will reach, and may exceed, $36,000,000. This would be an increase of $2,500,000 over last year's total and within $3,000,000 of the total gold production of the Dominion of Canada in 1929. Due to the recent strides of gold mining in Ontario, opinion in Canada expects Canadian output to overtake if not substantially exceed the United States by 1932.

The chief factor in this increase has been the Kirkland Lake camp, which has maintained an unbroken succession of gains for the last ten years. Production from the Kirkland Lake mines this year will have an estimated value of $16,000,000, as compared with $1,065,256 in 1920 and only $67,759 in 1913. Porcupine production, which has been more or less static for some years, is holding its own, and owing to the improved conditions at Hollinger Consolidated, may be expected to reach the $20,000,000 mark again next year.

In view of the current discussion over the world's gold supply, the question of the ultimate peak of Ontario production, although possibly irrelevant, is interesting. Apart from the possibility of the discovery of new mines, it is apparent that, with Ontario production of $36,000,000, bringing Canada's probable total output up to $42,000,000, the final capacity will not have been reached.

Owing to the fact that several attempts in recent years to develop properties in new and outlying fields have ended in disappointments, the immediate outlook for further increases in production is fairly definitely limited to the present producing fields. For purposes of calculation these may be confined to the four or five leading producers, leaving the speculative possibilities of the smaller producers such as Sylvanite and Kirkland Lake Gold in the Kirkland Lake field, and Vipond and Coniaurum in the Porcupine field to be decided by their actual performances in the future.

Details of output from individual mines have not yet been received, but, in the absence of any production from Dome, and in view of the fact that two of the smaller properties have been taken from the producing columns, the October total of $1,507,071 from Porcupine mines may be interpreted as a reflection of the improved state of affairs at Hollinger. The monthly production from McIntyre, Vipond, and Coniaurum shows comparatively little variation. With its new ore developments, Hollinger has an indicated life of at least five years on its present production basis of around $11,000,000 annually. Recovery from McIntyre Porcupine's operations has always checked closely with the grade of estimated ore reserves, so that on the proposed new basis of 2,000 tons daily, and an estimated recovery of $8.25 per ton, an annual production of around $5,775,000 may be anticipated after next year. Treating 300 tons of ore per day, Vipond production is at the rate of about $80,000 per month, or $960,000 annually, and officials are of the opinion this can be maintained for several years, in view of improved conditions underground and the possibility of new developments resulting from deeper work. Coniaurum operations, which showed a profit in September of $10,000, are now under the direction of Ventures, Ltd., and are providing an output of about $625,000 annually. Treating 1,500 tons of ore a day, Dome returns to the production lists with an output of about $3,500,000 annually, bringing the estimated total annual production from the Porcupine field, exclusive of unexpected developments, up to $21,860,000. Although this figure is necessarily tentative, the probability is that any revision, as far as the next four or five years are concerned, will be upward rather than downward.

Improvement at Kirkland Lake is due mainly to increased production from the three leading Kirkland Lake properties —Lake Shore, Teck Hughes and Wright-Hargreaves. Starting this fall, Lake Shore, through its new equipment, has a capacity of 2,000 tons daily, giving an output of at least $10,000,000 and, if official expectations are realized, of $12,000,000 annually. With the completion of its new unit next spring, Teck Hughes Gold will have a capacity of 1,250 tons daily and an officially estimated output of $7,865,000 annually. Wright-Hargreaves has improved its position to such an extent that the present production of about $2,300,000 appears assured for some time, with the probability of further increases. Sylvanite and Kirkland Lake Gold are both producing more gold than previously, and while they may not become large producers, are likely to continue their present rates of $750,000 and $475,000 a year respectively. Combining these figures, in view of the present plans of the operating companies, Kirkland Lake should, by the end of 1931, have an output equivalent to between $21,390,000 and $22,000,000 annually.

A feature of Ontario's gold output, sometimes forgotten, is the increase in value of gold as a by-product of nickel-copper refining and to a less extent from the copper-lead-zinc ores of the Sudbury district. Output from these sources, which for the first six months of 1930 was about $168,000, will gradually increase as the volume of production from the Frood mine increases, with an ultimate rate of $1,000,000 annually in view. This added to the calculated total from Porcupine and Kirkland Lake Mines, promises to bring Ontario's rate of production up to $44,000,000 annually.

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Treadwell Yukon Drift in Ore at Bodie, Calif.

Mill-grade ore has been struck on the 700 level of the old Red Cloud property, one of a group of claims at Bodie, Calif., which has been taken over by Treadwell Yukon. At the last report, the face of the drift was showing a streak of high-grade gold ore in addition to 4 ft. of mill-grade ore. The strike has been drifted on for 65 ft. It occurs in the Noonday vein, in a virgin section of the camp. The nearest of the old workings on this vein is several hundred feet distant and was operated through the Noonday shaft.

Treadwell Yukon now owns or has under option nearly all the old mines of the district. The latest acquisition is the old Standard mine, at the north end of the camp. Equipment for the 400-ton flotation plant, that is being built to treat dump material and low-grade surface ore, has been received, as well as the gasoline-powered 1½-cu.yd. shovel that will be used for surface operations. During the winter, supplies will be shipped in from Minden, on the Virginia City & Truckee Railroad.

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Errington Closes Mill But Will Continue Development

Operation of the 300-ton copper-lead-zinc concentrator at the Errington mine of Treadwell Yukon, near Sudbury, Ont., has been suspended. Development work is now being concentrated on drifting along the veins intersected by crosscutting north of No. 2 shaft on the 1,500 level. After development work on the 500 level proved a large low-grade deposit, the company announced that No. 2 shaft would be sunk to 1,500 ft. and that if work at that depth proved the continuity of the ore, a 2,000-ton concentrator, lead-copper smelter, and electrolytic zinc plant would be built. To date no ore has yet been struck on the 1,500 level. The working force has been cut in half. About 80 are left on the payroll.

Bob Held on Charges of Fraud in Mine Stocks

Charles V. Bob, promoter of mining and other stocks, who vanished from New York City on Oct. 6, preceding the collapse of three of the many companies with which he was associated, surrendered to the district attorney's office on Nov. 19. He pleaded not guilty to the charges of grand larceny in certain of his stock deals and was placed under $35,000 bail by Judge William Allen, of the General Sessions Court. His brother, Beverly Bob, and an associate, L. P. Jubien, were also put under bail. All three of the men furnished their bail immediately and have been allowed three weeks to make motions or alter their pleas.

Civil suits to recover from $1,000,000 to $2,000,000 from Bob and several of the firms which he created are said to be in the offing. The three companies that have been thrown into receivership since Bob's disappearance are Metal & Mining Shares, Charles V. Bob & Company, and Metal & Mining Founders Shares. The loss to investors in the collapse of these companies, according to Watson Washburn, Assistant Attorney General of New York, will range from $6,000,000 to $12,000,000.

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San Francisco Mines Resumes Recovery of Zinc From Ore

In October, San Francisco Mines of Mexico, operating at San Francisco del Oro, Chihuahua, Mexico, resumed production of zinc concentrate, which had been temporarily suspended because of the depressed metal market. The report for October shows that the company handled 33,890 tons of ore, from which 4,429 tons of lead concentrate and 4,242 tons of zinc concentrate was recovered at an operating profit of $49,759. The tonnage treated in the company's concentrator has been increasing slowly for the last year, as capacity is being raised from 800 to 1,400 tons daily.

EXCLUSIVE

CABLES

FROM CORRESPONDENTS IN THE PRINCIPAL MINING CENTERS

Reports Show Lower Profits for Many English Companies

London, Nov. 15.—The end of the fiscal year of many of the larger English-controlled mining companies on June 30 and Sept. 30 gives an opportunity of measuring, accurately, the effect on their profits of the lower metal prices that have prevailed so far in 1930. Consolidated Gold Fields of South Africa, one of the holding companies with most extensive mining interests, is paying a 7.5 per cent dividend on its outstanding ordinary shares. This compares with a 15 per cent dividend last year. However, Gold Fields has now 3,250,000 shares of £1 par outstanding as a result of its merger with South African Gold Trust and Amalgamated Mining, whereas last year it had only 2,500,000 shares out. The dividend, therefore, was really above expectations.

. . . . Santa Gertrudis, silver-gold producer of the Pachuca district, in Mexico, made a profit during its fiscal year, which ended June 30, of about £260,000, the quarterly reports indicate. This is a splendid showing when the drop in the price of silver is considered. Last year, earnings were £285,000. An interim dividend of 7.5 per cent has been paid and a final dividend of 5 per cent is expected. This compares with total payments of 15 per cent last year. Developments in the Dos Carlos property, which produces about half of the ore treated by the company, are reported as encouraging. The ore is said to contain a larger percentage of gold than formerly.

. . . . Burma Corporation, operating the Bawdwin lead-zinc mine in India, reports net profit for the year ended June 30 of £693,603 after depreciation and taxes, comparing with £1,054,842 in the preceding year. Production was increased and costs were lowered, but the decline in metal prices more than counterbalanced these favorable factors. The southern extension of the Chinaman orebody, discovered late last year, has now been driven on for 1,000 ft. on the No. 2 level and is apparently of great potential value. Development is continuing.

. . . . Trepca Mines, Ltd., treated 17,145 tons of ore in October, producing 3,352 tons of lead concentrates assaying 74.1 per cent lead and 29 oz. silver; and 2,114 tons of zinc concentrates assaying 49.1 per cent. Its new plant in Yugoslavia, rated at 500 tons' capacity, thus treated an average of 553 tons daily. The deep adit was advanced 866 ft., its total length now being 6,414 ft.

. . . . Naraguta Nigeria Tin has issued its report for the year ended March 31. It indicates the impossibility of Nigerian tin companies working profitably with the price of the metal at its current levels. The metal market is still apprehensive, however, for, even though Nigerian and most of the Bolivian production should cease, large stocks are still held by weak hands and consumption has given no evidence that it is increasing.

. . . . The deficit of Anglo-Chilean Consolidated Nitrate is now $11,000,000. Production has increased, but only 60 per cent of it was sold last year. Mining men here feel that the consolidation of the nitrate industry, under the aegis of the Chilean government, should improve the company's prospects.

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Daggafontein Preparing Plans for Mill Construction

Johannesburg, Nov. 15.—Directors of Daggafontein Mines, Ltd., state that development of the company's mining area, in the Far East Rand district of the Witwatersrand, has now indicated sufficient ore to justify erection of a reduction plant. Plans are therefore being proceeded with immediately. No statement is made as to the size, but the presumption is that it will be about the same size as the new East Geduld mill, now under construction, which will treat 60,000 tons of ore monthly. The company holds a total of 3,009 claims.

. . . . Development work at the Simmer & Jack property, on the Central Rand, has been disclosing a steadily improving grade of ore. Profits have been increasing slightly also, and are now at the rate of about £120,000 annually, compared with £79,905 last year. The Simmer & Jack is one of the oldest properties on the Witwatersrand, production having started in 1888. About 78,000 tons of ore are now being milled monthly, of an average grade of 22s. per ton.

. . . . Transvaal gold output for October was £3,937,884, a new high record for all time, surpassing the previous record, made in August, by about £23,000. The total for the year to date is £37,937,689, or about £1,000,000 higher than for the same period last year.

. . . . The gold producers have completed the presentation of their evidence to the Low-Grade Ore Commission, which suggests that definite action by the government may be expected soon. Lower working costs would undoubtedly stimulate production from a wide area around the Witwatersrand. The Labor party has made the proposal that the low-grade mines be subsidized by the rich ones, thus permitting extraction of otherwise unprofitable material. The proposal is not considered practicable by mine owners.

. . . . The value of the low-grade ore already developed on the Witwatersrand has been set at the stupendous figure of £500,000,000. In addition to this developed ore, must be added the additional low-grade material that will be exposed by development work from year to year but which will not be touched because it cannot be mined at a profit.

Roan Reports Expenses of £1,616,190 in 1930

London, Nov. 18. — Roan Antelope, expected to be the first of the new Northern Rhodesia copper mines to enter production, reports a total of £1,616,190 spent on development and construction work during the year ended June 30, 1930. The company states that it has nearly £2,000,000 in cash resources available for further construction work. Ore reserves on June 30 were estimated at 108,000,000 tons averaging 3.44 per cent copper, excluding 7,500,000 tons of ore under the river, which cannot be included in reserves. This estimate of reserves compares with 75,000,000 tons, averaging 3.3 per cent copper, made last year. The report states that the mine will undoubtedly be in condition to provide the mill with ore as soon as construction is completed. Production will be at the rate of 1,800,000 tons of ore annually at the start.

. . . . Rumors persist that a merger of Rhodesian Congo Border Concession with Bwana M'Kubwa Copper is being considered, although nothing official has been announced. Because of the alliance of N'Changa Copper with R.C.B.C., this consolidation, if effected, would control copper deposits that would make it a serious competitor to Chile Copper from the standpoint of ore reserves, and might eventually be the world's largest copper producer. At N'Changa, another drill hole, No. B33, has cut the high-grade orebody that extends into R.C.B.C. ground. The ore was cut at a depth of 1,315 ft. and has been drilled in for 20 ft. to date, showing an average of more than 7 per cent copper, chiefly sulphide.

. . . . A. D. Storke, of Roan Antelope and Rhodesian Selection Trust, has sailed for Madeira, where he will meet E. E. Barker, manager of Mufulira Mines, which is controlled by Rhodesian Selection Trust. They will discuss the position at the Mufulira property, now being equipped with a 5,000-ton plant. Drill hole No. 29, the deepest yet put down at the property, has cut ore at a depth of 3,280 ft. The ore showed a true width of 43 ft. of sulphide ore, averaging 4.37 per cent copper. This ore is in the lower formation. No ore was cut in the upper formation and only 8.5 ft. of 2.32 per cent copper in the middle lode.

. . . . Luiri Gold reports production of £2,842 in gold during October, from 1,506 tons of ore. Of this £100 was produced in September, but not included in the report, which showed output of £2,021 from 1,605 tons.

. . . . Rhodesia Broken Hill Development produced 1,360 long tons of electrolytic zinc in October. Its September output was 1,438 tons. The smaller total in October was due to experiments being carried on in the plant, and to interference from the construction work on the vanadium installation.

MARKET AND FINANCIAL NEWS

Agree on 20,000-Ton Cut in Copper Output

Acting for producers representing about 90 per cent of the world's output of copper, Copper Institute, on Nov. 13, announced that an agreement had been reached to curb production to an extent believed to be sufficient to prevent the further accumulation of supplies. The proposed reduction in output, which is to be voluntary, is expected to amount to at least 20,000 tons monthly, or about 15 per cent of the current rate of production.

The statement issued by the Copper Institute follows:

"Under auspices of the Copper Institute, a number of conferences have been held during the past two weeks at which was represented more than 90 per cent of the copper production of the world. At these meetings, the present critical status of the industry was considered and discussed.

"From this discussion it appeared that production, which in 1929 was stimulated to meet the peak demand of that year, has continued at a level higher than consumptive demand under the existing conditions of world-wide depression. The result has been the constant accumulation of stocks beyond any possibility of being liquidated under current conditions.

"Due to this fact and to the unforeseen falling off in demand due to the present industrial depression, the price of the metal has declined until it has reached a point below the average cost of production. The industry must face the fact of the necessity of curtailment of production. This curtailment can come in only one of two ways, either by the inevitable total suspension of many of the higher-cost units, causing unemployment at mines, mills, and reduction works with resultant distress in communities throughout the mining sections of the United States, or by the orderly reduction by the various units of the industry. It is hoped that by pursuing the latter method there will be brought about an equalization of current production to the consumptive demand without further addition to the already burdensome stocks that are jeopardizing the industry.

"The facts are as follows: On Jan. 1, 1929, by way of comparison, the total stocks of refined copper, as reported by the American Bureau of Metal Statistics, amounted to 65,466 short tons. On Jan. 1, 1930, this stock had been increased to 171,320 tons. On Nov. 1, 1930, the latest date at which stocks are reported by the same authority, the total amounted to 364,930 tons, indicating a current excess production throughout the year of approximately 20,000 tons of copper a month.

"Of the present world's output of copper, about 60 per cent is produced outside the United States and about 40 per cent within the United States.

"After a survey of the entire situation, the Copper Institute adopted a recommendation to the industry, urging that in its interest and in the interest of all dependent upon it for employment and subsistence, as well as of the public, so long as the present condition continues, such a reduction be made in current production as will prevent the increase of the existing stock.

"The present situation in the industry, together with all its surrounding facts and circumstances, has been fully presented to counsel.

"We have been advised that the recommendation of the institute is not violative of the law for the reasons that the present production is in excess of normal and reasonable market requirements, with resultant creation of excess stocks, and that there is no price-fixing agreement. That the reduction made by each individual member is purely voluntary and entirely without coercion or compulsion; that in view of the abnormal surplus stock now on hand and of the fact that the recommended reduction will not materially reduce that surplus, that present stocks plus the suggested production are more than ample to satisfy any possible demand, and that the reduction is to operate only during the existing condition, and is entered into and confined in good faith to the purpose of meeting the present business disaster and depression."

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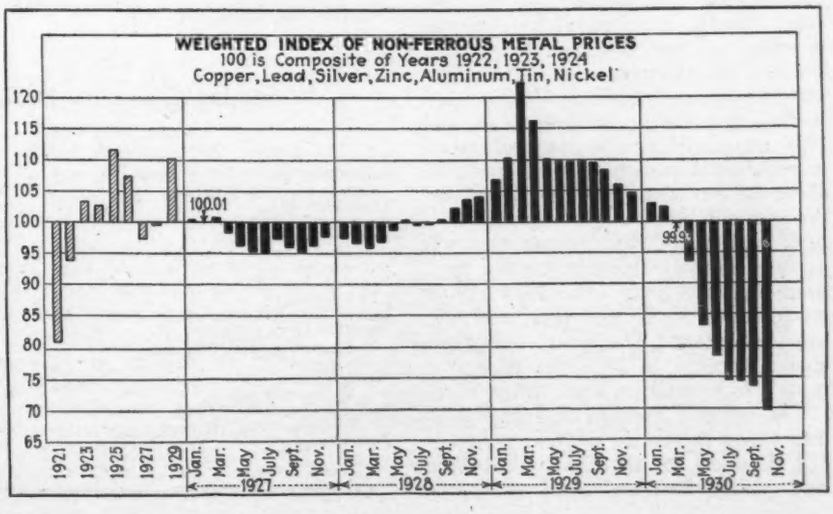
Financial Notes

WALKER MINING, operating a copper property in California, reports the sale of 8,926 tons of concentrate and high-grade ore in the third quarter of 1930 for $431,850. Net income, after depreciation and taxes, was $25,380, despite the average price of copper of about 10.7c. a pound.

CALLAHAN ZINC-LEAD, developing the Galena mine in the Coeur d'Alene district, Idaho, reports a deficit for the third quarter of 1930 of $21,170. Only one carload of concentrate was produced.

NEVADA CONSOLIDATED reports net profits, before depletion and federal taxes, of $143,556 in the third quarter of 1930, compared with $161,870 in the preceding quarter and $5,517,409 in the third quarter of 1929. Copper production was 33,373,311 lb., at a cost of 9.28c. a pound, compared with 35,740,442 lb., at a cost of 10.28c. a pound, in the preceding quarter. Recovery of copper per ton of ore treated was 22.35 lb., compared with 20.74 lb.



Consumption Holds Key to Copper Prosperity

S. D. Strauss
Assistant Editor

The sword of Damocles still dangles over the heads of the copper producers. It weighs not less than 605,075 tons, according to the latest report of the A.B.M.S. Part of it is blister and part of it is refined, but all of it is copper. Some of this material, of course, is necessary for maintenance of operations, but at least two-thirds is surplus.

World-wide curtailment of output, officially announced on Nov. 13, does not solve the copper situation. The producers themselves admitted as much when they said that the production cut of 20,000 tons of copper monthly, to which they have agreed, will not materially reduce present surplus stocks. New mines are coming, or will soon come, into production. The older producers cannot continue indefinitely curtailing their output to make room for the newcomers. Before the copper-mining industry can safely be said to be back on its feet, shipments to consumers must increase.

What hope is there of an increase in consumption and how large must it be to absorb both the current stocks and the imminent new production? These are the questions that every copper producer must wish he could answer. In the days of 18c. copper, the statement was widely heralded that copper consumption increases, on an average, 6 per cent annually. Predictions of a copper famine were heard and the discovery of Northern Rhodesia's immense copper deposits was proclaimed a godsend to a copper-hungry world.

The only reliable index of copper consumption is the monthly rate of shipments from American smelters and refineries, compiled by the A.B.M.S. The amount of secondary metal and metal from mines in the Eastern Hemisphere that is moving into industry can only be estimated. An examination of the A.M.B.S. figures shows how widely consumption has ranged from year to year. In the accompanying table, the monthly average for each year since 1923 of all shipments from American smelters and refineries is shown. Assuming that the years 1925, 1926, and 1927 were normal, the average annual increase in shipments would seem to be about 3.5 per cent over the record for the previous year. Figures have, therefore, been compiled indicating what the average monthly shipments would have been had each year since 1924 shown an increase of 3.5 per cent over the previous year. The year 1924 was chosen because in 1923 the effects of post-War liquidation were still evident.

The monthly average of actual shipments over the entire six-year period is 124,252 tons. On the basis of a 3.5 per cent yearly increase since 1924, the monthly average would have been 123,035 tons. This does not mean that the 3.5 per cent increase is necessarily the actual rate of increase in copper consumption. Too many complicating factors exist to permit so generalized an assumption. In fact, no particularly good reason exists why copper consumption should increase at any given rate for a period of more than two or three years. If the table indicates anything, it is that the normal rate of shipments from American copper plants at present would be about 135,000 to 140,000 tons monthly. When those figures are approached, the worst should be over—for the time being, at least.

Shipments of Copper From American Refineries

Year	Shipments (*a*)	Per Cent (*b*)	Assumed Shipments (*c*)
1923	96,449	..	.....
1924	109,982	14	.....
1925	117,977	7	112,800
1926	119,003	1	116,700
1927	122,225	2.5	120,700
1928	138,140	13	124,900
1929	142,167	3	129,300
1930	106,000 (*d*)	26	133,800
Averages (*e*)	124,252	..	123,035

(*a*) Monthly average of actual shipments, short tons. (*b*) Per cent of increase shown over previous year. (*c*) Assumed shipments had the rate of increase after 1924 been 3.5 per cent annually for each year. (*d*) Estimated; for first ten months was 104,600. (*e*) For the period 1924–1930.

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Teck Output and Profits Gain

Production of gold by Teck-Hughes Gold Mines, operating in Canada, showed a considerable gain in the fiscal year ended Aug. 31, 1930, as compared with the previous year's record. As costs dropped, profits showed a more than corresponding increase. Bullion production was valued at $5,415,970, compared with $4,889,127; and the net surplus for the year, after deductions for depreciation and taxes, was $3,051,886, compared with $2,543,518. Costs per ton of ore treated dropped from $6.576 a ton to $6.41, and per ounce of gold produced from $9.208 to $8.342. The company again paid dividends of 60c. a share during the year. Surplus is estimated at $2,291,191.

Stocks of Copper Increased 7,961 Tons in October

Total stocks of blister and refined copper in the hands of North and South American producers increased 7,961 tons during October, according to the summary of copper statistics compiled by the A.B.M.S.

Total shipments of refined copper for the month of October were 113,949 tons, against 103,042 tons in September, 95,129 tons in August, and 117,902 tons in July. Domestic shipments in October totaled 75,703 tons, against 65,169 tons in September. Export shipments for October were 38,246 tons, compared with 37,873 tons in September.

Copper Statistics

(American Bureau of Metal Statistics)

In Tons of 2,000 Pounds

Production:	September	October
Mines, United States	56,584	55,804
Blister, North America (*a*)	85,580	84,395
Blister, South America (*a*)	26,374	27,836
Refined, No. & So. America	116,004	118,229
World, blister basis	152,405	(*c*)
Stocks (end of month):		
No. & So. America:		
Blister (*b*)	236,464	240,145
Refined	360,650	364,930
Totals	597,114	605,075
Great Britain (*d*)		
Refined	2,575	5,042
Other forms	3,893	3,217
Totals	6,468	8,259
Havre	6,392	6,638

(*a*) Includes direct-cathode copper. (*b*) Includes in process. (*c*) Not yet available. (*d*) Official warehouses only.

U. S. Mine Production

	September	October
Porphyry mines	20,531	20,816
Lake mines	7,624	5,695
Vein mines	24,327	25,293
Custom ores	4,100	(*a*) 4,000
Total crude production	56,584	55,804
Daily rate	1,886	1,800

(*a*) Partly estimated.

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Tennessee Copper & Chemical will hold a special meeting of its shareholders Dec. 2 to consider changing the company's name to Tennessee Corporation. The directors believe the name would be more suitable in view of the broad scope of the company's business. During the present year the company has continued to earn profits well in excess of dividend requirements.

Mining Company Dividends for November, 1930

Companies in the United States	Situation	Per Share	Total Disbursements
American Smelting & Refining	Various	$1.00 Q	$1,829,940
Anaconda Copper, c, z, l, s	Various	0.62½ Q	5,536,469
Bunker Hill & Sullivan, l, s	Idaho	0.50 MX	163,500
Freeport Texas Sulphur	Texas	1.00 Q	729,783
Homestake Mining, g	S. Dakota	0.50 M	125,580
Mohawk Mining, l, s	Michigan	0.25 Q	28,750
National Lead "B"	Various	1.50 Q	154,913
New Jersey Zinc	Various	0.50 Q	981,632
United Verde Extension, c	Arizona	0.50 Q	525,000
Vanadium Corp. of Am	Various	0.75 Q	283,775
Companies in Other Countries			
Andes Copper	Chile	0.25 Q	773,333
Cerro de Pasco, c, s	Peru	1.00 Q	1,122,842
Granby Consolidated, c	Canada	0.50 Q	225,000
Hollinger Consolidated Gold	Canada	0.05 M	246,000
International Nickel, pfd., c, n	Canada	1.75 Q	158,959
Teck-Hughes, g	Canada	0.15 Q	713,574
Total			$13,599 050

c, copper; z, zinc; l, lead; s, silver; g, gold; n, nickel; Q, quarterly; MX, monthly and extra.

Domestic Lead Stocks Gain on Drop in Shipments

Shipments of lead reported by refiners in the United States during October totaled 45,129 tons, against 52,451 tons in September, according to the American Bureau of Metal Statistics. The October total was the lowest for all months so far this year. The monthly average for the first ten months of 1930 was 55,372 tons.

Domestic production in October was 50,402 tons, against 48,491 tons in September. The daily rate for October was 1,626 tons, against 1,616 tons in the preceding month, and an average of 1,721 tons for the January-October period.

The decline in shipments was largely responsible for a gain of 10,706 tons in stocks. Stocks of refined lead at the end of October amounted to 84,375 tons, against 73,669 tons at the end of September.

Production statistics, stocks, and shipments, in tons, follow:

Production:	Sept.	Oct.
From domestic ore	48,491	50,402
Secondary and foreign	4,746	4,967
Totals	53,237	55,369
Stock at beginning (a)	72,832	73,669
Total supply	126,069	129,038
Stock at end (a)	73,669	84,375
Shipments by difference	52,400	44,663
Shipments reported	52,451	45,129

(a) Domestic only.

The United States lead refinery statistics account for refineries at Omaha, Selby, Perth Amboy, Carteret, Collinsville, East Chicago, Herculaneum, Grasselli, Federal, Kellogg, Galena, Newark, Matawan, Indianapolis, Joplin, and Ontario.

Domestic production of refined lead, by months, together with the daily rate, in tons, follows:

	1929		1930	
	Prod.	Rate	Prod.	Rate
January	63,165	2,038	49,991	1,613
February	55,546	1,984	54,125	1,933
March	61,110	1,971	56,552	1,824
April	58,040	1,935	55,547	1,852
May	63,632	2,053	52,818	1,704
June	58,380	1,946	50,721	1,691
July	59,155	1,908	51,538	1,663
August	58,503	1,887	52,980	1,709
September	58,106	1,937	48,491	1,616
October	64,707	2,087	50,402	1,626
November	61,352	2,045	.....	....
December	55,144	1,779	.....	....
Totals	716,840	1,964	523,165	1,721
Monthly av'ge	59,737	....	52,317	....

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U. S. Silver Production Shows Moderate Upward Trend

During the month of October the United States produced 3,910,000 oz. of silver, against 3,780,000 oz. in September, and 5,130,000 oz. in October, 1929.

Canadian production in October amounted to 2,291,000 oz., against a total of 3,486,000 oz. in September, and 2,605,000 oz. in October last year.

Peru produced 1,480,000 oz. of silver in October, which contrasts with 1,495,000 oz. in the preceding month, and 1,556,000 oz. in October, 1929.

Australian production for October was 709,000 oz., against 663,000 oz. in September, and 854,000 oz. in October last year.

Mexico produced 9,154,000 oz. of silver in September, against 7,755,000 oz. in August, and 7,905,000 oz. in July of this year. Mexican production in September, 1929, was 9,649,000 oz.

Burma is credited with an output of 540,000 oz. for September, against 580,000 oz. in the preceding month.

World production of silver in September, according to the American Bureau of Metal Statistics, was 19,118,000 oz., contrasted with 17,350,000 oz. in August, and 16,513,000 oz. in July. World production in September, 1929, was 19,751,000 oz. The so-called world's total comprises about 87 per cent of the total production of silver.

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Inco's Third-Quarter Earnings

Net profit of International Nickel for the third quarter of 1930 was $2,013,961, compared with $3,267,730 and $4,616,144 in the previous quarters of the year. Lessened activity in nickel buying, and the drop in the prices of copper and platinum, important by-products, were the causes of the lower earnings. Total profits in the first nine months of $9,897,836 compared with $16,865,754 earned in the corresponding period of 1929. The company's surplus on Sept. 30 is put at $22,902,071.

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Financial Notes

EL ORO MINING & RAILWAY, operating silver properties in Mexico, reports a profit of £45,399 in the year ended June 30, 1930. Corresponding profit in the previous fiscal year was £25,385. Production from the La Noria mine was 4,337 metric tons of concentrate, averaging 18.8 kg. of silver and 13.97 grams of gold per ton, as well as 119 metric tons of shipping ore, averaging 11.6 kg. of silver and 4.6 grams of gold per ton.

BROKEN HILL PROPRIETARY, operating a lead-zinc mine at Broken Hill, New South Wales, and iron-ore properties in South Australia, reports net profit in the year ended May 31, 1930, of £161,890, compared with £332,671 in the previous fiscal year. The company has liquid assets of £487,988. Production was 16,250 tons of lead concentrate from mine ore and 20,751 tons from tailing re-treatment.

RHODESIAN SELECTION TRUST, exploration and holding company with interests chiefly in the copper deposits of Northern Rhodesia, reports expenditures of £455,144 during the year ended June 30, 1930. Total expenditures up to that date were £757,827. Investments of the company, largely shares in the subsidiary Mufulira operation, are valued at £383,556 and cash on hand at the end of the year was £51,298.

TONOPAH MINING, silver-gold producer operating in Nevada and Colorado, has abandoned plans for reorganization at the present, because of the depression in the security markets. At the June meeting of the stockholders, the president of the company, Walter Haehnlen, suggested reorganization of the company because of the low price of silver which had closed the principal operation at Tonopah.

CALUMET & ARIZONA, operating copper mines at Bisbee and Ajo, reports net income, after depreciation and taxes, of $85,296 in the third quarter of 1930, compared with $611,699 in the second quarter, and $803,366 in the first. Production of copper was 24,014,152 lb.

ALASKA JUNEAU during October mined and trammed to mill 327,140 tons of ore, from which estimated profit was $142,000, or 43.41c. per ton.

Complete Market News and Prices

THE semi-monthly magazine you are now reading carries only a condensed review of important market news and price movements. For buyers and sellers of ores, metals, minerals, and scrap who require reliable information as soon as it is available, we now provide *Metal and Mineral Markets*, which goes to press at the close of the metal-market week each Wednesday. It is printed at high speed and is in the mails that evening. In compact form, ready for insertion in a ring binder, it is ideal for desk and reference use. It carries the standard *E.&M.J.* quotations used in contracts the world over, recognized as authoritative and dependable. *Metal and Mineral Markets* is priced to subscribers in the United States and its possessions at $2 per annum; to countries in the Americas but outside the United States, $5; elsewhere, $10 yearly: 52 issues. Address *M.& M.M.*, 36th St. and 10th Ave., N.Y.City.

Copper Curtailment Plan Sends Price Sharply Higher—Lead Active

New York, Nov. 20, 1930.—Just as soon as the news of the success of the copper curtailment plan was announced the price of the metal advanced sharply. At the top figure named by leading producers—12c. delivered Connecticut—the buying came to an abrupt halt. The cessation of activity brought out offerings from some sellers at concessions, and toward the close the price was wholly nominal. The excitement in copper spread to the other major metals, but, with the exception of tin, prices showed little change. Quicksilver was offered at slightly lower levels. Bismuth was advanced 25c. a pound on Nov. 19.

Large Copper Sales

In the last two weeks about 90,000 tons of copper were sold in the domestic market, most of which was disposed of at close to the 9½c. basis. The upward tendency in prices first made itself felt on Nov. 12, the day before the official report on the curtailment plan was announced, when copper sold at 10c. Excitement ran high after the initial advance took place, and on Nov. 15 most producers went to 12c. Little copper was sold in the domestic market in the period from Nov. 17 to 19, inclusive. A moderate tonnage could have been picked up at concessions from the 12c. level, prices named on Nov. 19 ranging down to 10½c., and the market was a wholly nominal affair toward the close. Resale copper also was pressing on the market and added to the general confusion.

The export price was raised from 9.80c. to 10.30c. on Nov. 13. On the following day the export price was established at 10.80c. Copper Exporters, Inc., raised the quotation on Nov. 15 to 12.30c., c.i.f., which held up to the close of the period under review. Export business for the current month to date has been excellent, totaling 68,000 long tons.

The immediate future of the market is uncertain. Domestic consumers have already ordered copper for about five months' requirements. Actual consumption of the metal has been stimulated by the higher prices, and it is fairly certain that this will be reflected in larger shipments by producers. The curtailment in production should soon become a factor and trade authorities are confident that the statistical position of copper will, in next six months, show substantial improvement.

Lead Business Improves

Spurred on by the developments in copper, consumers of lead purchased a large tonnage. Cable makers, who booked an excellent volume of business on the strength of the sudden change in the copper situation, were the principal buyers, though virtually all classes of consumers of lead were well represented in the business booked. Moderate improvement in the automotive industry was reflected in a better demand for lead from battery manufacturers. The October statistics were unfavorable in that the domestic stocks showed a gain of slightly more than 10,000 tons. This increase resulted chiefly from the decline in October shipments. With production still tending downward, and a moderate increase in the demand, the feeling prevails that the November statistics will show some improvement.

Tin in Demand

The London market for tin moved largely in sympathy with copper. Early in the period prices were sharply higher, but subsequent unsettlement in copper soon took some of the edge off the bull movement. Prices here, as usual, followed London's lead. A good tonnage of tin was disposed of, domestic consumers taking on metal for prompt as well as forward delivery. Reports received in New York on activity in the different producing centers were conflicting, but operators appeared to show little interest in such developments, owing to the excitement injected into the market by the copper situation.

Zinc Unsettled

Demand for zinc has quieted down considerably, and prices lost some of the ground gained during the spurt in activity which followed closely on assurances to the effect that production would be curtailed to an extent sufficient to arrest the steady accumulation of supplies. A fair tonnage sold as high as 4.40c., St. Louis, early in the fortnight, but on the last day of the period there were sellers at prices ranging from 4.25c. to 4.30c. The October statistics showed stocks at the end of the month of 141,232 tons, against 132,947 tons a month previous. Total shipments during the month of October were 32,655 tons, against 30,173 tons in September.

Silver Steady

The price of silver continues on a steady basis on fair orders from both China and India. Output has increased in the leading producing centers, but operators have shown no inclination to exert any pressure on the market.

Other Metals

Quotations cover wholesale lots, f.o.b. New York, unless otherwise specified. London prices are according to latest mail advices.

ALUMINUM—Per lb., delivered, Alcoa commercial and mill ingot, 99 and 98 per cent, 23.30c.; Alcoa No. 12 alloy, 22c.; metallurgical ingot, 94 per cent plus, 23.30c.; 98@99 per cent, 22.90c. London, £85, less 2 per cent, per long ton, for 98 per cent ingots and bars.

ANTIMONY—Per lb., duty paid, Chinese, spot 7⅛c.; futures, 7.05c. Cookson's "C" grade, spot 12¾c. "C.M.C." grade, 99.9 per cent, spot, 10¾c. London, Chinese, spot, £24 per long ton.

BISMUTH—Per lb., in ton lots, $1.25. London, 5s.

CADMIUM—Per lb., 70c. London. 2s. 2d.

CHROMIUM—Per lb., 97@98 per cent grade, 85@90c. per lb. contained chromium, maximum 1 or 2 per cent iron.

COBALT—Per lb., delivered: Metal imported from Begium in the form of rondelles, 97@99 per cent, spot, $2.50. Discounts on contracts. London, spot, 10s. Nominal.

INDIUM—Per gram, minimum 99 per cent, $14@$15.

IRIDIUM—Per oz., $190@$200 for 98 @99 per cent sponge and powder. London, £37@£39.

MAGNESIUM—Per lb., 12-lb. ingots (4x4x16 in.), 99½ per cent, 65c.@$1, depending on quantity; 2½- or 3-lb. sticks (1⅜ in.), 70c.@$1.05, depending on quantity. London, 2s. 9d.@3s. for 99 per cent ingots or sticks.

MANGANESE—Per lb., 95@97 per cent, 42c.

MOLYBDENUM—Per lb., in 50-to 100-lb. lots, C.P. powder, $9.50; 97 per cent $6.50. (Usually sold as calcium molybdate or ferromolybdenum, which see.)

NICKEL—Per lb., ingot 35c.; shot, 36c.; electrolytic, 35c. (99.9 per cent), for single lots of spot metal. Contracts,

E.&M.J. Weighted Index of Non-Ferrous Metal Prices

100 Is Composite for 1922-3-4

1920	130.92
1921	80.80
1922	93.94
1923	103.43
1924	102.63
1925	111.74
1926	107.74
1927	97.54
1928	99.78
1929	110.33

	1928	1929	1930
January	97.54	106.86	102.94
February	96.73	110.37	102.28
March	96.22	122.71	99.93
April	97.14	116,36	93.24
May	99.05	110.03	83.41
June	100.16	109.66	78.57
July	99.69	109.58	74.58
August	99.85	109.81	74.41
September	100.53	109.29	73.42
October	102.34	108.52	69.63
November	103.83	106.09	....
December	104.28	104.75	....

Daily Prices of Metals

Nov.	Electrolytic Copper	Straits Tin	Lead		Zinc
	Refinery	New York	New York	St. Louis	St. Louis
6	9.275	25.70	5.10	4.95	4.40
7	9.275	25.55	5.10	4.95	4.40
8	9.275	25.55	5.10	4.95	4.40
10	9.275	25.45	5.10	4.95	4.375
11	9.275	25.125	5.10	4.95	4.30@4.35
12	9.775	25.00@25.50	5.10	4.95	4.30@4.35
Av'ge	9.358	25.438	5.100	4.950	4.371
13	10.075	26.35	5.10	4.95	4.35
14	10.80	26.75	5.10	4.95	4.35
15	11.40	26.70	5.10	4.95	4.35
17	11.275@11.775	26.00@26.25	5.10	4.95	4.35
18	10.775@11.775	25.70	5.10	4.95	4.275@4.35
19	10.275@11.775	25.875	5.10	4.95	4.25@4.30
Av'ge	11.017	26.250	5.100	4.950	4.331

Average prices for calendar week ended November 8, 1930, are: Copper, 9.275c.; Straits tin, 25.630c.; New York lead, 5.100c.; St. Louis lead, 4.950c., Zinc, 4.365c.; and Silver, 35.729c.

Average prices for calendar week ended November 15, 1930, are: Copper, 10.100c.; Straits tin, 25.938c.; New York lead, 5.100c.; St. Louis lead, 4.950c.; Zinc, 4.346c.; and Silver, 36.175c.

The above quotations are our appraisal of the major markets for domestic consumption based on sales reported by producers and agencies. They are reduced to the basis of cash, New York or St. Louis, as noted. All prices are in cents per pound.

Copper, lead, and zinc quotations are based on sales for both prompt and future deliveries; tin quotations are for prompt delivery only.

In the trade, copper prices are quoted on a delivered basis; that is, delivered at consumer's plant. As delivery and interest charges vary with the destination, the figures shown above are net prices of refineries on the Atlantic seaboard. Delivered prices in New England average 0.225c. per pound above those quoted.

Quotations for copper are for the ordinary forms or wirebars and ingot bars. For ingots an extra 0.05c. per pound is charged; for slabs, 0.075c.; and for cakes, 0.125c. up, depending on weight. Cathodes are sold at a discount of 0.125c. per pound.

Quotations for zinc are for ordinary Prime Western brands. Zinc in New York is now quoted at 0.35c. per pound above St. Louis, this being the freight differential. The contract price for High-Grade zinc delivered in the East and Middle West is 1c. above the St. Louis price for Prime Western.

Quotations for lead reflect prices obtained for common lead, and do not include grades on which a premium is asked.

Silver, Gold, and Sterling Exchange

Nov.	Sterling Exchange "Checks"	Silver		Gold London	Nov.	Sterling Exchange "Checks"	Silver		Gold London
		New York	London				New York	London	
6	4.85½	36⅛	16⅜	85s0¾d	13	4.85 7/16	36⅛	16 11/16	85s0¾d
7	4.85 9/16	36⅛	16⅜	85s0¾d	14	4.85⅝	36⅛	16 11/16	85s 1d
8	4.85½	36	16 11/16	.....	15	4.85 7/16	36¼	16⅜	.....
10	4.85½	36	16 11/16	85s1½d	17	4.85 7/16	36	16 11/16	85s1¼d
11	4.85 7/16	35⅞	16⅜	85s1½d	18	4.85⅝	35⅞	16 9/16	85s 1d
12	4.85½	35⅞	16 9/16	85s0¾d	19	4.85⅝	36	16⅜	85s 1d

Average of week ended November 12: Silver, 36.000c.; Sterling Exchange, $4.85500.
Average of week ended November 19: Silver, 36.063c.; Sterling Exchange, $4.85406.

New York quotations are as reported by Handy & Harman and are in cents per troy ounce of silver, 999 fine. London silver quotations are in pence per troy ounce of bar silver, basis of 925 fine. Sterling quotations represent the demand market in the forenoon. Cables command three-sixteenths cent premium.

London

Nov.	Copper Standard		Electrolytic	Tin		Lead		Zinc	
	Spot	3 M		Spot	3 M	Spot	3M	Spot	3 M
6	43 3/16	43⅛	45½	113	114½	15⅜	15 13/16	15⅛	15⅜
7	43 7/16	43⅜	45¼	112⅜	113½	15⅜	15⅝	14 11/16	15 5/16
10	44 7/16	44 7/16	45¼	112	113½	15½	15⅝	14 11/16	15¼
11	44½	44⅜	45¼	111½	112 7/8	15⅜	15 9/16	14⅛	15 1/16
12	45	45½	47½	110⅜	111⅛	15 7/16	15 9/16	14 11/16	15 1/16
13	49¼	49⅜	51	115	116½	16	16⅛	14 13/16	15½
14	50¾	50¾	53½	116¾	118⅛	16 11/16	16⅜	14 13/16	15½
17	49⅜	49⅝	52½	115	116⅜	16 13/16	16 7/8	15 5/16	15⅞
18	47⅝	47⅞	50	113¼	114½	15⅞	15⅞	14 13/16	15 5/16
19	46	46	50	113¼	114⅜	16⅛	16 1/16	14 9/16	15 1/16

Prices for lead and zinc are the official prices for the morning session of the London Metal Exchange; prices for copper and tin are the official closing buyers' prices. All are in pounds sterling per long ton (2,240 lb.).

30@33c. London, per long ton, £170@£175.

OSMIUM—Per oz., $60@$70. Nominal. London, £16@£16 10s.

PALLADIUM—Per oz., $22@$23. London, £3 15s.@£4.

PLATINUM—Per oz.; Official price of leading interest, $36. Market quiet but steady. Cash transactions between dealers and refiners at several dollars less. London official price, £7. Average price of Colombian crude, basis 85 per cent platinum, for the month of October was $25.75 per oz.

QUICKSILVER—Per 76-lb. flask, $106 @$108, delivered. London £22⅝.

RADIUM—Per mg. radium content, $50 in lots of 4 grams or more, to $65 for 1 gram; smaller quantities, $70.

RHODIUM—Per oz., $50. Nominal.

RUTHENIUM — Per oz. $44@46. Nominal. London, £9½@£10.

SELENIUM—Per lb., $1.80@$2, depending on quantity, for black, powdered, 99.5 per cent pure. London, 7s. 8d.

SILICON—Per lb., minimum 97 per cent Si, maximum 1 per cent Fe, 15@17c.

TANTALUM—Per kilo, $128 for C.P. sheet. Quiet.

TELLURIUM—Per lb., $2.

THALLIUM—Per lb., $12.50@$15.

TITANIUM—Per lb. in 50- to 100-lb. lots, 75 per cent, $5.

TUNGSTEN—Per lb. contained tungsten, 98 per cent, powdered, $1.55.

Metallic Ores

Prices in tons of 2,000 lb., or in "units" of 20 lb., unless otherwise stated.

ANTIMONY ORE—No sales reported. London, per long ton unit, 3s. 9d.@4s. for 60 per cent sulphide ore.

BERYLLIUM ORE—Per unit of BeO, minimum 11 per cent BeO, $4@$5, f.o.b. mines. Per lb. BeO contained, 40c., c.i.f. European ports

CHROME ORE—Per long ton, c.i.f. Atlantic ports, Indian ores, $19.50 for 46@48 per cent Cr_2O_3 ore, and $24 for 50@51 per cent ore. London, 80s. for 48 per cent Rhodesian, and 80s.@98s. for Indian and New Caledonian.

IRON ORE—Per long ton, Lower Lake ports. Lake Superior ores:

Mesabi, non-bessemer, 51½ per cent iron, $4.50. Old Range, non-bessemer, $4.65.

Mesabi, bessemer, 51½ per cent iron, $4.65. Old Range, bessemer, 51½ per cent, $4.80.

Colorado, per long ton unit, f.o.b. mines, 20 to 23 per cent, 6½c.

Eastern ores, cents per unit, delivered at furnaces: Foundry and basic, 56 to 63 per cent, 10c.

Foreign ores, alongside docks Atlantic ports, cargo lots, cents per unit:

North African and Swedish, low-phosphorous, 10@10½c.

Spanish and North African basic, 50@60 per cent, 9@9½c.

Swedish foundry or basic, 65@68 per cent, 10c.

Newfoundland foundry, 55 per cent iron, 9c.

MANGANESE ORE—Per long ton unit of Mn, c.i.f. North Atlantic ports, cargo lots, exclusive of duty: Brazilian, 46@48 per cent Mn, 25c.; Chilean, 47 per cent minimum, 30½c.; Indian, 48@50 per cent, 27@28c.; Caucasian, 52@55 per cent, 27@28c.; South African, 52@54 per cent, 27@28c., nominal, Inactive. Domestic, f.o.b. *Colorado* mines, 20 to 25 per cent, 30c.

Per ton in carload lots:

Chemical grades, powdered, coarse or fine, minimum 80 per cent MnO_2, Brazilian or Cuban, $60. Javan or Caucasian, 85 per cent minimum, $60. Domestic, 70 to 72 per cent, $60, f.o.b. mines.

MOLYBDENUM ORE—Per lb. of contained MoS_2, nominally 35@40c., delivered Pittsburgh. London, per long ton unit, nominal at 33@35s. for 80@85 per cent concentrate.

TANTALUM ORE—Per lb. Ta_2O_5, 75c. for 60 per cent ore. Per lb., f.o.b. *New Mexico* mines, crude ore with minimum 40 per cent Ta_2O_5, 85c.; 35 per cent, 65c.

TIN ORE — No market in United States. London, returning charge on 60 per cent Bolivian, £10 per long ton; on 70 per cent Nigerian, £6 17s. 6d.

TITANIUM ORE — Per gross ton, ilmenite, 45@52 per cent TiO_2, f.o.b. Atlantic seaboard, $10@$12, according to grade and impurities. Low-grade domestic, 32 to 35 per cent, about $7@$8. Rutile, per lb., guaranteed minimum 94 per cent concentrate, 10c.

TUNGSTEN ORE—Per unit of WO_3, N. Y.: Chinese wolframite, $12.50, duty paid. Bolivian scheelite, $12.25, and domestic, $13.50; both nominal. Crude low-grade ores, f.o.b. *Colorado*, $10 basis for 60 per cent WO_3.

VANADIUM ORE—Per lb. V_2O_5 contained, 27c., f.o.b. shipping point.

ZIRCON ORE — Per ton, 55 per cent ZrO_2, f.o.b. Atlantic seaboard, $40@$45 in 30-ton lots. Crude granular zircon, $70, f.o.b. Suspension Bridge, N. Y.

Non-Metallic Minerals

Prices received for non-metallic minerals vary widely and depend upon the physical and chemical characteristics of the commodity. Hence the following quotations can serve only as a general guide to the prices obtained by producers and dealers in different parts of the United States for their own product. In the last analysis the value of a particular non-metallic mineral can be ascertained only by direct negotiation between buyer and seller.

Tons of 2,000 lb., unless otherwise noted.

AMBLYGONITE — Per ton, f.o.b. mines, 8@9 per cent lithium oxide, $50@$60.

ASBESTOS — Per ton, f.o.b. Quebec mines, tax and bags included: Crude No. 1, $350@$400, crude No. 2, $250@$275; spinning fibers, $150@$175; magnesia and compressed sheet fibers, $100@$125; various grades shingle stock, $45@$65; various grades paper stock, $30@$35; cement stock, $15@$20; floats, $10@$12. Market dull despite a decline in prices.

Per ton c.i.f. New York: Rhodesian crude No. 1, $350; No. 2, $250.

Per ton, c.i.f. New York: Russian crude, No. 1, $210; No. 2, $160; No. 3, $50.

BARIUM CARBONATE (Witherite) — Per ton, 90 per cent, 200 mesh, $47; 100 mesh, $44.

BARYTES—F.o.b. mines, bags extra:

Georgia: Barytes ore, crude, $6.50 per long ton.

Missouri: Per ton, water ground and floated, bleached, $23, car lots, f.o.b. works. Crude ore, minimum 93 per cent $BaSO_4$, less than 1 per cent iron, $7; 1 per cent iron and 93 per cent $BaSO_4$, $6.50, f.o.b. mines.

BAUXITE—Per long ton: Domestic ore, chemical, crushed and dried, 55 to 58 per cent Al_2O_3, 1.5 to 2.5 per cent Fe_2O_3, $6.50@$8.25, f.o.b. *Alabama* and *Arkansas* mines. Other grades, 56 to 59 per cent Al_2O_3, 5 to 8 per cent SiO_2, $6.50@$8, f.o.b. *Arkansas* mines. Pulverized and dried, 56 to 59 per cent Al_2O_3, 8 to 12 per cent SiO_2, $12@$12.25, f.o.b. *Arkansas* mines; abrasive grade, crushed and calcined, 78 to 84 per cent Al_2O_3, $15@$17.50, f.o.b. *Arkansas* mines.

Per metric ton, foreign, c.i.f. Atlantic ports: Dalmatian, 50 to 55 per cent Al_2O_3, 1 to 3 per cent SiO_2, $4.50@$6.50; one dealer reports $7 for material running 52@54 per cent alumina and 1.50 per cent silica; market fair. Istrian, 54 to 57 per cent Al_2O_3, 3 to 5 per cent SiO_2, $5.50@$7; French, 56 to 59 per cent Al_2O_3, 2 to 4 per cent SiO_2, $6@$8; 56 per cent Al_2O_3, 1.50 per cent SiO_2, $7; 58 per cent Al_2O_3, 3@4 per cent SiO_2, $6.50.

BENTONITE—Per ton, f.o.b. Wyoming mines, dried and crushed, in bulk, $8; in bags, $10. F.o.b. Chicago, selected air-floated, $25.

BORAX — Per ton, carload lots, in bags, crystals, $56; granulated, $50; powdered, $57.50; f.o.b. shipping point.

[1]CELESTITE—Per ton in carload lots, 90 per cent $SrSO_4$, finely powdered, $27.

CHINA CLAY (KAOLIN)—Per ton, f.o.b. *South Carolina* mines, crude lump, No. 1, $4.50; crushed to ¼ in., $6; pulverized, $9.

Florida, washed and crushed, No. 1 $12.50; No. 2, $12.

Imported English, f.o.b. American ports; lump, $15@$25 in bulk.

EMERY—Per ton, f.o.b. *New York*, domestic crude ore, $10. Other American ore, delivered to grinders, per gross ton, $15; Turkish and Naxos ore, $30@$35. F.o.b. *Pennsylvania*, in 350-lb. kegs, Turkish, Khasia, and Naxos grain emery, 6½c. per lb.; American, 3½c.

FELDSPAR—Per ton, ground: Canada, $22; New England, $21.50; Southern, $30; Trenton, $21; Western, $24.

Virginia, No. 1, 325 mesh, $18; 200 mesh, $15@$16; 160 mesh, $14; No. 1 glassmakers, $11.

New Mexico: Crude clean No. 1 potash spar, $4.75; ground, $9.50.

FLUORSPAR — Per ton, f.o.b. *Kentucky* and *Illinois* mines:

Gravel, not less than 85 per cent CaF_2, and not over 5 per cent SiO_2, $17.25. Foundry lump, 85-5, $18@$20. Ground, 95 to 98 per cent CaF_2, and not over 2½ per cent SiO_2, $32.50 in bulk; $36.50 in bags or barrels. *Colorado* mines, 82-5, $12.75.

FULLER'S EARTH — Per ton, f.o.b. *Colorado*, $18, various finenesses to minus 90 mesh.

F.o.b. *Georgia*, 30 to 60 mesh, $18; 15 to 30, $16,50; 200 up, $10; 100 up, $7.

GARNET—Per ton, f.o.b. *New Hampshire* mines: crude or mill run, $45; unwashed grades, $85; washed, $125.

New York: Adirondack garnet concentrates, $85.

Spanish grades, $60, c.i.f. port of entry.

GILSONITE — Per ton, carload lots, f.o.b. mines *Colorado:*

Selected grade, $33; seconds (mine run), $25.50.

GRAPHITE—Per lb., f.o.b. *New York:* Ceylon lump, 7@8½c.; chip, 6@7c.; dust, 2@3c.; Madagascar flake, 6@8c.

No. 1 flake, 8@16c.; fine ground, 5c. upward; amorphous, 3c. upward.

Crude amorphous graphite, $15@$35 per ton, according to grade.

GREENSAND — Per ton, f.o.b. cars, *New Jersey:* Screened and bagged, best grade, in carload lots, $20. No. 2 grade, $15.

GYPSUM—Per ton, f.o.b. mill, crushed rock, *Iowa*, $2.50; *Ohio* and *New York*, $3. Ground, *Ohio*, $4; *Iowa*, $6. Agricultural, $6@$7. Calcined $6@$9.

IRON OXIDE (See Ocher)—Per lb.: Standard Spanish red, 3@4½c.; domestic earth, 2@4½c.

KAOLIN—See China Clay.

LEPIDOLITE—Per ton, $50@$60 for ordinary grades. Nominal.

LIMESTONE—Per ton, f.o.b. shipping points, depending on location, either lump or crushed, 25c@$1.75.

Agricultural, $1 up to $6 per ton.

MAGNESITE—Per ton, f.o.b. *California* steel mill points, dead-burned, $29. *Washington:* Dead-burned grain magnesite, $22.

MICA—Per ton, f.o.b. *New Mexico*, scrap, white, $21; off color, $18. Punch, white, for disks, per lb., 10c.; for washers, 8c.

Per ton, f.o.b. *New Hampshire*, roofing mica, $23; snow, $34; 40 mesh white, $40; 60 mesh, $48; 100 mesh, $60; 200 mesh, $75. Clean dry mixed bench and mine scrap, $13.

Per lb., f.o.b. *North Carolina*: Punch, 4@6c.; 1½x2 in., 25@35c.; 2x2, 45@60c.; 2x3, 85c.@$1; 3x3 $1.40@$1.60; 3x4, $1.80@$2; 3x5, $2@$2.25; 4x6, $2.75@$3; 6x8, $3.50@$3.75; 8x10, $5@$7.50. These prices apply both to No. 1 and No. 2 mica. Black-stained mica takes a discount of

10 to 25 per cent from this schedule. White North Carolina mica, 70 mesh, $60 to $80. Biotite, or black mica, $15 a ton, unground.

MINERAL BLACK—(Graphitic shale)—Per ton, 325 mesh, 75 per cent carbon, $22.50, f.o.b. *Virginia.*

MONAZITE—Per ton, minimum 6 per cent ThO_2, $60.

OCHER — Per ton, f.o.b. *Georgia* mines, $17.50 in sacks; $20 barrels; second grade, $10. Buff clay, 98 per cent through 325 mesh, $18.

F.o.b. *Virginia,* dark yellow, 300 mesh, 60 per cent ferric oxide, in jute bags, $19.50.

PHOSPHATE—Per long ton, f.a.s. or f.o.b. mines:

Florida, pebble, f.a.s., for export: 76@77 per cent, $7.15; 75 per cent, $6.40; 74@75 per cent, $6.15; 70 per cent, $4.65; 68 per cent, $4.10.

Florida, pebble, domestic: 76@77 per cent, $6.50; 74@75 per cent, $5.50; 72 per cent, $4.50; 70 per cent, $4.

Tennessee, ground, 80 per cent through 300 mesh, 33 per cent P_2O_5, $11.80 per ton, bags extra.

POTASH—Per ton, contracts:

	Bags	Bulk
Muriate of potash, 80@85 per cent, basis 80 per cent	$37.15	$35.55
Sulphate of potash, 90@95 per cent, basis 90 per cent	48.25	46.65
Sulphate of potash-magnesia, 48@53 per cent, basis 48 per cent	27.80	26.20
Manure salt, 30 per cent	22.15	19.15
Manure salt, 20 per cent	15.65	12.65
Kainit, 14 per cent	12.70	9.70

Prices are delivered to Atlantic ports. Discounts up to 4 per cent for early shipment. Spot prices, $1.25@$1.50 per ton higher than on contract.

PUMICE STONE—Per lb., in barrels, powdered, 2½@4c.; selected lump, 5@7c.

PYRITES—Per long ton unit of sulphur, c.i.f. United States ports, guaranteed 48 per cent sulphur, Spanish, 13@13¾c.

[1]QUARTZ ROCK CRYSTALS—Per lb. in ton lots, colorless, clear but flawed, pieces ¼ to ½ lb. in weight, 20c. Flawless, for optical purposes, four times above price; larger crystals still higher.

SILICA—Per ton, water ground and floated, in bags, f.o.b. Illinois: 325 mesh, $16@$40 for 92 to 99½ per cent grades. Dry ground, air-floated, 325 mesh, 92@99½ per cent silica, $14@$30. Market steady. Glass sand, f.o.b. producing plant, $1.25@$5 per ton; molding sand, 50c.@$3.50; blast sand, $1.75@$6.

[1]SPODUMENE — Per ton, $50@$60 depending upon lithium content.

[1]STRONTIANITE — Per ton, lump in carload lots, minimum 88@91 per cent $SrCO_3$, $100.

SULPHUR—Per long ton for domestic market, $18 f.o.b. Texas mines; $22 for export, Atlantic ports.

TALC — Per ton, carload lots, f.o.b. works, containers included unless otherwise specified.

New Jersey: Soapstone, ground, $10 @$12.

New York: Double air-floated, short fiber, 200 mesh, $13.75; 325 mesh, $14.75.

Vermont: 99 per cent through 200 mesh, extra white, bulk basis, $8@$8.50; 97 to 98 per cent through 200 mesh, medium white, $7.50@$8. Packing in paper bags, $1 per ton extra.

Virginia: 200 mesh, $6.25@$7.90; 325 mesh, $9@$11.

TRIPOLI — Per ton, burlap bags, paper liners, minimum carload 30 tons, f.o.b. *Missouri:* Once ground through 40 mesh, rose and cream colored, $16. Double ground through 110 mesh, rose and cream, $18. Air-floated through 200 mesh, rose and cream, $22.50; mill run, $16.

Rolled Metals

COPPER — Per lb., sheets, hot-rolled, 20¾c.; wire, f.o.b. mill, 12¾c. Nominal.

LEAD SHEETS—Per lb., full rolled, 8c. clipped, 8¼c.

MONEL METAL—Per lb., sheets, full finished, 42c.; rods, hot-rolled, 35c.

MUNTZ METAL—Per lb., rods, 17⅜c.; plates, 20⅛c.

NICKEL—Per lb., sheets, full finished, 52c.; rods, hot-rolled, 45c.

NICKEL SILVER — Per lb., sheets, 10 per cent, 25½@26c.; 18 per cent, 28¾@29¼c. Wire and rods, 10 per cent, 29c.; 15 per cent, 32¼c.; 18 per cent, 36½c.

PHOSPHOR BRONZE—Per lb., sheets and rods, 5 per cent tin, 32c.; wire, 5 per cent, 32½c.; 10 per cent, 38c.

ZINC SHEETS — Per lb., 9½c., f.o.b. works; ribbon, 9c.; 7 per cent discount on orders for 18 tons or more.

Alloys

FERROCHROME — Per lb. of contained chromium, 4 to 6 per cent carbon, 65 to 70 per cent chromium, 11c., delivered, on contracts; spot, 11½c. Containing 2 per cent carbon, 65 to 70 per cent chromium, 17½c.; maximum 0.10 per cent carbon, 26c.

FERROMANGANESE — Per gross ton furnace; domestic and foreign, 78@82 per cent, $94@$99, contracts, depending on quantity. Spiegeleisen, 19@21 per cent, $33 for spot carloads.

FERROMOLYBDENUM—Per lb. of Mo, f.o.b. shipping point, 50@60 per cent Mo, $1.

FERROPHOSPHORUS—Per ton, 18 per cent P, $91; electrolytic, 24 per cent, $122.50, f.o.b. *Alabama* and *Tennessee.*

FERROSILICON — Per gross ton, delivered, 50 per cent, $83.50; 75 per cent, $130; 14@16 per cent, $39, f.o.b. Niagara Falls, N. Y. Spot shipments $5@$10 per ton higher on 50 and 75 per cent grades.

FERROCARBONTITANIUM — Per ton, $150, f.o.b. producer's plant.

FERROTUNGSTEN—Per lb. of W contained, 75@80 per cent W, $1.10@$1.15, f.o.b. works.

FERROVANADIUM—Per lb. of V contained, delivered, $3.15@$3.50.

SILICOMANGANESE — Per long ton, carload contracts, delivered, $135 for maximum 2½ per cent carbon; $145 for maximum 1 per cent carbon.

SILICON ZIRCONIUM—Per lb., 47@52 per cent Si, 35@40 per cent Zr, 18@21c.

ZIRCONIUM FERROSILICON—Per gross ton, 12@15 per cent Zr, 39@43 per cent Si, $103.50@$108.50.

Metallic Compounds

ARSENIOUS OXIDE (White arsenic)—Per lb., 4c., delivered, all positions. London, per long ton, £17¾ for Cornish white.

CALCIUM MOLYBDATE OR MOLYTE—Per lb. of contained Mo, 95c.

COBALT OXIDE—Per lb., black, 70@71 per cent contained Co, $2.10. London, 8s. for black; 8s. 10d. for gray.

COPPER SULPHATE (Blue Vitriol)—Per lb., in car lots, 4.25c. for either large or small crystals.

GERMANIUM DIOXIDE—Per gram, in 200- to 300-gram lots, $3.50.

SODIUM NITRATE—Per 100 lb., crude natural, in bags ex vessel, Atlantic ports, $2.02.

SODIUM SULPHATE (Salt Cake)—Per ton, bulk, f.o.b. works, $15@$18.

ZINC OXIDE—Per lb. in bags, in car lots: Lead-free, 6½c.; 10, 20 or 35 per cent leaded grades, 6¼c.; French red seal, in bags, 9⅜c.

ZIRCONIUM DIOXIDE—Per lb. in 100- to 500-lb. lots, 87 per cent ZrO_2, commercial, 50c.

Refractories

CHROME BRICK—Per ton, f.o.b. shipping point, $45.

FIRECLAY BRICK — Per M., first quality, $43, *Ohio, Kentucky, Central Pennsylvania;* second quality, $35@$38.

MAGNESITE — Brick, per ton, f.o.b. works, 9-in. straights, $65. Dead-burned grain, $40, f.o.b. Chester, Pa., or Baltimore.

SILICA BRICK—Per M., *Pennsylvania,* $43; *Alabama,* $50@$51; *Illinois* and *Indiana,* $52.

ZIRKITE—Per lb., powdered, 65@70 per cent ZrO_2, 3½c. Brick, straights, 80c.@$1 each.

Iron, Steel, and Coke

IRON—Per gross ton, Valley furnaces: Bessemer, $17.50, basic and No. 2 foundry, $17.

STEEL—Per gross ton, base prices, Pittsburgh, billets and slabs, $31; plates and structural shapes per 100 lb., $1.60; soft steel bars, $1.60@$1.65.

COKE—Per ton, Connellsville furnace, $2.60. Connellsville foundry, $3.50@$4.85. Byproduct coke, Ohio and Kentucky (Connellsville basis), $5.50; Buffalo and Detroit, $8@$8.50; Birmingham, $5.

[1]Price furnished by Foote Mineral Company, Philadelphia.

Mining Share Prices—Month of October, 1930

Company Name	Metals Produced	Location of Properties	High	Low	Last
NEW YORK STOCK EXCHANGE					
Ahumada Lead	Lead silver	Mexico	0.62½	0.50	0.50
Alaska Juneau	Gold	Alaska	7.12½	4.87½	6.25
Am. Metal	Lead, silver, zinc	Various	23¾	18½	20½
Am. Metal, pfd	Copper, gold	Various	104	100	100
Am. Sm. & Ref	Lead, copper, silver	Various	57¾	51	52¾
Am. Sm. & Ref., 2d pfd.			101¾	99	99
Am. Sm. & Ref., pfd.	Gold, zinc		136¾	134½	135
Am. Zinc, L. & S.	Zinc, lead	Various	8.00	5.25	5.62½
Am. Zinc, L. & S., pfd.			57½	49	49
Anaconda	Copper, zinc, silver	Various	38	33	35¼
Andes Copper	Copper, silver	Chile	17¾	14¾	14¾
Butte C. & Z.	Manganese, zinc	Montana	2.12½	1.75	2.00
Butte & Superior	Zinc, silver	Montana	1.50	1.12½	1.12½
Callahan Zinc-Lead	Lead, zinc	Idaho	0.87½	0.87½	0.87½
Cal. & Arizona	Copper, gold, silver	Arizona	45½	33½	36½
Cal. & Hecla	Copper	Michigan	10¾	8.50	9.75
Cerro de Pasco	Copper, silver, lead	Peru	39	30½	31½
Dome Mines	Gold	Ontario	9.12½	7.87½	8.75
Federal M. & S.	Lead, zinc, silver	Idaho, Tri-State	100	97½	99
Federal M. & S., pfd.			99	98	98
Freeport Texas	Sulphur	Texas	42½	31¾	33½
Granby Con	Copper, silver, gold	Brit. Col.	18	12½	14
Greene Cananea	Copper, silver, gold	Mexico	55	50	50
Homestake	Gold	So. Dakota	83	79	82
Howe Sound	Copper, lead, zinc	Various	27½	21½	23¾
Inspiration	Copper	Arizona	11	8.00	8.75
International Nickel	Nickel, copper	Ontario	22⅜	16½	17½
Int. Nickel, pfd.			121	120½	120⅜
Kennecott	Copper, gold, silver	Various	30½	24¾	25½
McIntyre-Porcupine	Gold	Ontario	18¾	17¼	18
Magma Copper	Copper, silver, gold	Arizona	29	20	21⅛
Miami Copper	Copper	Arizona	12	8.00	8.75
Mother Lode	Copper, silver	Alaska	1.00	0.75	0.75
National Lead	Lead, zinc	Various	126	116½	120
National Lead, pfd. A			142	141	141
National Lead, pfd. B			118½	117	118½
Nevada Con.	Copper, gold, silver	Various	12⅛	9.25	10½
Park Utah Con.	Zinc, silver, lead	Utah	1.75	1.37½	1.37½
Patiño M. & E.	Tin	Bolivia	14	9.12½	11½
Phelps Dodge	Copper, gold, silver	Various	29½	23½	24
Rand Mines	Gold	Africa	32	32	32
St. Joseph Lead	Lead, zinc, silver	Various	36	28	28½
Seneca Copper	Copper	Michigan	1.75	1.50	1.75
Tennessee C. & C.	Copper, su. acid	Tennessee	9.62½	8.25	9.00
Texas Gulf	Sulphur	Texas	56⅜	50½	52½
U. S. S. R. & M.	Silver, gold, lead	Various	22	19	21
U. S. S. R. & M., pfd.	Zinc, copper		44½	43	43⅜
Utah Copper	Copper, gold, silver	Utah	....	....	148*
Vanadium Corp.	Vanadium, ilmenite	Various	67¼	46⅜	48⅛
NEW YORK CURB EXCHANGE					
Aluminum Co. of Am.	Aluminum	Various	204½	150	168
Alum. Co. of Am., pfd.			110	108½	109
Anglo-Chilean Con.	Nitrate	Chile	23	14½	20
Bunker H. & S.	Lead, silver, zinc	Idaho	58½	58½	58½
Carnegie Metals	Silver, gold	Mexico	5.00	4.00	4.37½
Con. Coppermines	Copper, gold, silver	Nevada	3.37½	2.00	2.62½
Copper Range	Copper	Michigan	7.75	7.75	7.75
Cresson Con.	Gold	Colorado	0.31½	0.25	0.25
Cusi Mexicana	Lead, zinc, silver	Mexico	0.62½	0.50	0.50
Evans-Wallower	Lead, zinc	Various	1.75	1.00	1.25
Federated Metals	Trading	Various	13½	11½	12⅜
Hecla Mining	Lead, silver, zinc	Idaho	9.62½	9.12½	9.50
Hollinger Con.	Gold	Ontario	6.50	5.62½	5.75
Hudson Bay M. & S.	Copper, zinc	Manitoba	6.50	4.87½	4.87½
Iron Cap Copper	Copper, silver, gold	Arizona	1.50	1.50	1.50
Mayflower Assoc.	Holding	Various	54	41	45
Mining Corporation	Silver, lead, zinc	Canada	1.12½	1.00	1.00
New Jersey Zinc	Zinc, lead, silver	Various	65	48	52⅜
Newmont Mining	Holding, copper, gold	Various	80	57½	57½
N. Y. and Honduras	Silver, gold	Honduras	10¾	9.50	10½
Nipissing	Silver	Ontario	1.25	0.93¾	1.12½
Noranda Mines	Copper, gold, silver	Quebec	20	13½	15½
Ohio Copper	Copper, lead, gold	Utah	0.50	0.37½	0.37½
Premier Gold	Silver, gold	Brit. Col.	1.12½	0.75	0.87½
Quincy	Copper	Michigan	8.75	8.25	8.75
Shattuck Denn	Copper, gold, silver	Arizona	4.12½	2.50	3.12½
So. Am. Gold & Plat.	Platinum, gold	Colombia	1.12½	1.00	1.12½
Teck-Hughes	Gold	Ontario	6.50	5.87½	6.00
Tonopah Mining	Silver, gold, copper	Various	....	....	0.62½
United Eastern	Silver, lead	Mexico	....	....	0.06¼*
United Verde Ex.	Copper, gold, silver	Arizona	9.00	7.00	7.62½
United Zinc Sm.	Lead, zinc	Tri-State	....	....	3.50*
Utah-Apex	Lead, zinc, copper	Utah	1.50	1.25	1.50
Yukon Gold	Gold	Yukon	1.25	1.25	1.25
BOSTON STOCK EXCHANGE					
Ariz. Comm.	Copper, gold, silver	Arizona	1.37½	1.25	1.25
East Butte	Copper, gold	Montana	1.25	0.68¾	1.12½
Isle Royale	Copper	Michigan	6.00	4.62½	4.62½
Mohawk Mining	Copper	Michigan	22	18½	19
Old Dominion	Copper, gold, silver	Arizona	4.25	4.00	4.00
Utah Met. & Tunnel	Copper, lead, gold	Utah	0.35	0.20	0.26
MONTREAL					
Asbestos Corp.	Asbestos	Quebec	0.75	0.25	0.25
Asbestos Corp., pfd.			2.00	1.00	1.00
Consolidated M. & S.	Lead, zinc, silver	Canada	170	120	134

Company Name	Metals Produced	Location of Properties	High	Low	Last
TORONTO STANDARD STOCK AND MINING EXCHANGE					
Abana Mines	Copper, zinc, silver	Quebec	0.31	0.20	0.28
Amulet Mines	Copper, zinc, silver	Quebec	0.45	0.24	0.30
Base Metals	Lead, zinc, silver	Brit. Col.	2.00	0.80	1.00
Barry-Hollinger	Gold	Ontario	0.13½	0.07½	0.08
Canam Metals	Lead, zinc, silver	Various	0.12	0.12	0.12
Castle-Trethewey	Silver	Ontario	0.16	0.15	0.15
Central Manitoba	Gold	Manitoba	0.10	0.05	0.06
Falconbridge	Nickel, copper	Ontario	1.85	1.25	1.45
Howey Mines	Gold	Ontario	0.29	0.19	0.20
Keeley	Silver	Ontario	0.28	0.27	0.27
Kirkland Lake	Gold	Ontario	0.51	0.40	0.41
Lake Shore	Gold	Ontario	24	21½	21 5/16
Sherritt Gordon	Copper, zinc, silver	Manitoba	1.50	0.82	0.91
Siscoe Gold	Gold	Quebec	0.46	0.30	0.31
Sylvanite	Gold	Ontario	0.58	0.41	0.57
Treadwell Yukon	Lead, zinc, silver	Various	1.55	1.25	1.25
Ventures	Holding	Various	0.70	0.35	0.45
Vipond Con.	Gold	Ontario	1.10	0.80	0.92
Waite-A.-M.	Copper, zinc, gold	Quebec	2.50	1.80	2.20
Wright-Hargreaves	Gold	Ontario	1.86	1.60	1.70
ST. LOUIS, CINCINNATI, AND DENVER					
Consolidated L. & Z.	Lead, zinc	Tri-State	4.00	3.00	3.00
Eagle-Picher	Lead, zinc, silver	Various	8.00	6.75	6.87½
Eagle-Picher, pfd.			101½	100	100
Empire Chief	Lead, zinc, silver	Colorado	0.02½	0.02	0.02
New El Paso	Gold	Colorado	0.03½	0.02	0.03
Star of Utah	Lead, zinc, silver	Utah	0.67	0.50	0.60
Tungsten Production	Tungsten	Colo., Nev.	0.15	0.09½	0.09½
SAN FRANCISCO, LOS ANGELES, AND COLORADO SPRINGS					
California Copper	Copper, gold, silver	California	0.87½	0.50	0.75
Golden Cycle	Gold	Colorado	12½	12	12
Idaho-Maryland	Gold	California	0.32	0.17½	0.24½
Portland	Gold	Colorado	0.01	0.00½	0.00½
Tom Reed	Gold	Arizona	0.81	0.72	0.72½
United Gold	Gold	Colorado	0.07½	0.07	0.07½
SPOKANE					
Constitution	Lead, zinc, silver	Idaho	0.09½	0.05	0.08½
Dayrock	Lead, silver	Idaho	1.68	1.10	1.10
Goldconda	Lead, zinc, silver	Idaho	0.45	0.30	0.33½
Jack Waite Con.	Lead, zinc, silver	Idaho	0.04½	0.03	0.03
Mexican Premier	Lead, silver, gold	Mexico	0.30	0.22	0.23½
Montana Mines	Gold, silver	Montana	0.22½	0.17	0.19½
Noble Five	Lead, zinc	Brit. Col.	0.05½	0.02	0.03½
Pend Oreille	Zinc, silver, lead	Wash	0.75	0.50	0.70
Sherman Lead	Lead, silver	Idaho	0.55	0.42	0.42
Sunshine Mining	Silver, lead, copper	Idaho	2.03	1.85	1.90
Tamarack & Custer	Lead, silver	Idaho	0.39½	0.33	0.33
SALT LAKE CITY					
Chief Con.	Lead, silver, gold	Utah	0.82	0.72	0.72
Combined Metals	Zinc, lead, silver	Various	0.13½	0.10	0.10
Eureka Bullion	Lead, silver, gold	Utah	0.22	0.14½	0.14½
Eureka Lilly	Lead, silver, gold	Utah	0.30	0.20	0.20
Moscow Silver	Silver, lead	Utah	0.71	0.70	0.70
New Quincy	Lead, silver, zinc	Utah	0.09¾	0.06½	0.06¾
North Lily	Lead, silver, gold	Utah	1.25	0.75	0.75
Park Bingham	Lead, zinc, silver	Utah	0.03	0.01½	0.01½
Park City Con.	Lead, zinc, silver	Utah	0.30	0.23	0.23
Rico Argentine	Zinc, lead, silver	Colorado	0.06½	0.06½	0.06½
Silver King Coal	Lead, silver, zinc	Utah	6.65	6.50	6.60
Tintic Lead	Lead, silver, copper	Utah	1.20	1.00	1.20
Tintic Standard	Lead, gold, silver	Utah	5.10	4.50	4.90
Walker Mining	Copper, gold, silver	California	1.85	1.55	1.67½
‡LONDON					
Anglo American	Holding	Various	19/4½	15/–	16/3
Aramayo Mines	Tin, bismuth, silver	Bolivia	22/6	21/3	22/6
Burma Corporation	Lead, silver, zinc	India	11/–	9/–	9/9
Bwana M'Kubwa	Copper	Rhodesia	12/–	8/–	8/7½
Camp Bird	Holding	Various	7½d	5½d	6d
Fresnillo	Silver, lead, zinc	Mexico	7/6	7/6	7/6
Frontino & Bolivia	Gold	Colombia	7/6	7/6	7/6
Lake View & Star	Gold	Australia	9/7½	4/3	7/9
Mexican Corporation	Copper, zinc	Mexico	5/3	3/6	4/–
N'Changa Copper	Copper	Rhodesia	64/7½	39/4½	43/9
Oroville Dredging	Gold	California	2/–	1/3	2/–
Rhodes. Congo Border	Copper	Rhodesia	265/–	200/–	205/–
Rhodes.-Select. Trust	Copper	Rhodesia	27/6	19/–	19/4½
Rio Tinto	Copper, pyrites	Spain	705/–	586/3	607/6
St. John del Rey	Gold	Brazil	19/3	16/7½	17/6
San Francisco Mines	Zinc, lead, silver	Mexico	16/1½	13/3	14/3
Santa Gertrudis	Silver, gold	Mexico	....	....	7/9*
Selukwe	Holding	Africa	3/1½	2/3	2/6
So. American Copper	Copper	Venezuela	1/7½	1/–	1/6
Tanganyika	Holding	Africa	33/1½	25/7½	27/6
Wiluna Gold	Gold	Australia	16/6	13/3	13/9
Union Minière	Copper	Bel.Congo	7,440	6,000	6,225†

Salt Lake Stock Exchange courtesy J. A. Hogle & Company, Toronto Standard Stock Exchange courtesy the Arthur E. Moysey Company, Spokane Standard Exchange courtesy the Pohlman Investment Company. *Not traded in. †Belgian Francs. ‡The above London quotations are for the month ended Oct. 20.